

PUNJAB WATER RESOURCES MANAGEMENT PROJECT

TERMS OF REFERENCE

CONSULTING SERVICES FOR DETAILED DESIGN FOR IRRIGATION CANAL AND LINK CANAL PROJECTS

1. BACKGROUND

1. Pakistan's population of 210 million in 2017 is projected to reach 229 million in 2025. The increase in population combined with improved living standards will require 40% to 50% additional food by 2025. This additional food can be achieved through expanded irrigated area and agricultural productivity, wherever opportunities exist. Increased agriculture activities will also contribute to job creation and poverty reduction in the province's rural communities. Punjab, Pakistan's second largest province, contributes about 80% to the country's food requirements and 57% to the production value of the country's agriculture. Irrigated agriculture accounts for more than 26% of Punjab's gross domestic product and employs over 40% of its labor force. Punjab manages an existing irrigation system serving 8.4 million hectare (ha) irrigated land. The value of Punjab's irrigation infrastructure has been estimated at \$20 billion (2005-06 estimates).

2. Agriculture production in Punjab has benefitted from the Indus Basin Irrigation System (IBIS) that provides irrigation water to 15 million ha of land, of which about 60% lies in Punjab. The IBIS is the lifeline of the Punjab agriculture sector. However, deteriorated century-old structures and inefficient water management within irrigation schemes and /or on farm resulted to the unreliable surface irrigation water delivery in the IBIS. Some cultivable lands in Punjab remain outside of the IBIS and rely on unpredictable scarce rainfall or ground water that may lower the water table. Although the Government of Punjab has placed a high priority on improving irrigation infrastructure and its efficiency¹, additional efforts are required for improved agriculture productivity and water use efficiency to achieve economic growth target and food security in the province.

3. Among the priority projects identified by the Punjab provincial government to improve irrigation infrastructure that will enhance water availability and, thus, increase productivity of the agriculture sector; four projects involve construction, rehabilitation, remodeling, and upgradation of irrigation canals. A list of these priority projects is in Table 1.

¹ The Punjab Irrigation Department (PID) has taken actions by working closely with ADB, the World Bank, and Japan International Cooperation Agency for the improvement of irrigated agriculture. ADB's \$700 million multitranchise financing facility for Punjab Irrigated Agriculture Investment Program has successfully supported the improvement of the irrigation infrastructure, on-farm agriculture of over 2 million ha, and institutional reforms.

Table 1: List of PID's Priority Canal Projects²

No.	Project^a	Culturable Command Area, (ha)	Estimated Cost (US\$ million)
1	Remodeling and Upgrading of Dera Ghazi Khan Canal System Project	384,082	68
2	Rehabilitation and Upgrading of Upper Jhelum Canal System Project	244,328	174
3	Greater Thal Canal (Phase-III) Project (Dhingana Branch System, Noorpur Branch System and Mehmood Sub Branch System) Project	440,850	600
4	Remodeling of R-Q, Q-B & B-S Link Canals Project	1,083,159	50
	Total	2,152,419	892

4. The provincial government, through the Government of Pakistan, has requested the Asian Development Bank (ADB) to provide support for improved project preparation of these priority projects. A project readiness financing (the PRF) is proposed as the financing modality.

2. OBJECTIVES OF THE ASSIGNMENT

5. The PRF will support accomplishing high project preparation readiness of these priority projects by (i) reviewing and revising the feasibility studies and making up their deficiencies to ensure the efficacy and compliance with funding agency's requirements; (ii) preparing detailed design and procurement documents; and (iii) providing other project readiness support.

6. Feasibility studies for the Package I priority projects were carried out by various consultants. The detailed design of Greater Thal Canal (Phase-III) was also carried out previously. The proposed consulting services package will: (i) scrutinize the priority of the projects; (ii) review / update existing feasibility studies; (iii) conduct detailed engineering design, including preparation of drawings and priced bill of quantities for all priority projects (for GTC project, the existing WAPDA detailed design will be updated while for the other three projects, detailed design will be prepared) and (iv) provide project readiness support, including the preparation of bidding documents and PC-Is for all priority projects. The priority of projects may be updated during the PRF. Detailed design of individual projects will be conducted / updated sequentially, starting from higher priority or urgent project(s).

7. A brief description of the PID's proposed priority projects is in **Annexure A**.

3. SCOPE OF SERVICES, TASKS AND EXPECTED DELIVERABLES

8. More specifically, the scope of services for the consultants will include but not limited to:

² The list of the priority project(s) may be revised.

General Scope:

- (i) perform specific tasks for review and updating the feasibility studies for the identified priority projects to ensure the efficacy and compliance with funding agency's and government's acceptable requirements, including undertake of additional social, agricultural, hydrological, topographical and geotechnical investigation and surveys;
- (ii) prepare feasibility level outputs documenting the viability of civil works while adequately addressing both environmental and resettlement issues and outlining in detail the implementation arrangements, service delivery mechanisms and monitoring and evaluation procedures;
- (iii) carry out required additional field surveys and geotechnical, hydrological and other investigations necessary for final designs of the identified priority projects;
- (iv) provide necessary support for their independent technical and economic reviews and oversight to ensure improved quality in the updated feasibility studies, design and other related issues; based on the fresh topographic surveys, investigations and studies carried out, prepare layouts of the irrigation and drainage system for the project area;
- (v) prepare recommendations of water allowance, irrigation intensity, and cropping pattern; prepare capacity and command statements for the watercourses, channels, dams, and weirs; determination or location of each hydraulic structure including outlets; identification of crops suitable for command area; recommend efficient irrigation system models; prepare water balance; collection of agricultural data from primary and secondary resources, and estimation of present agriculture situation in the command area and in the adjacent irrigated areas; formulation of agriculture parameters including land-use, cropping pattern, season of crops, quantity of inputs, cultural operations and production of outputs;
- (vi) carry out required additional surveys, geotechnical investigations, hydrological analysis and other such activities where necessary to provide a basis for final design of all hydraulic structures.
- (vii) prepare Chakbandi plan (document showing characteristics of area served by the outlet) of each outlet showing field levels, location of nakkas for new canal systems.
- (viii) design and prepare longitudinal profiles and cross sections for irrigation and drainage channels;
- (ix) prepare hydraulic, structural, electro-mechanical and geotechnical design criteria;
- (x) identify various hydraulic structures for efficient conveyance of irrigation and drainage flows;
- (xi) design necessary flood protection works for main canal, distribution system and other project works as required;

- (xii) carry out physical model studies for flood protection works for main canal, distribution system and other project works where needed;
- (xiii) prepare / update detailed engineering design for all facets of construction works of the identified priority projects including tender and construction drawings of the irrigation systems covering bridges, canal falls, cross regulators, head regulators, aqueducts, outlets and all associated cross drainage works including electro-mechanical works and will be designed strictly in accordance with the accepted state of the art methods and irrigation science, hydraulics, soil mechanics and structural engineering. Moreover, effective innovations to mitigate flood damages need to be included;
- (xiv) analyze all hydraulic design options for ensuring satisfactory sediment transport and minimizing cost requirements without sacrificing system performance or control required for efficient and equitable distribution of irrigation water;
- (xv) prepare rules for optimal sediment control into head regulator and amend Operation and Maintenance Rules of falls and other civil structures accordingly;
- (xvi) identify minor and distributary canals those involve community participation, conduct walk-thorough pre-design exercise with the community and consider related resettlement and environmental issues in the design;
- (xvii) use focus groups and stakeholder consultation to develop a rehabilitation process for distributary and minor canals that fully involves farmers in general in both the detailed design and implementation of system improvements;
- (xviii) develop relevant operation and maintenance (O&M) strategies for main canals, distribution systems and barrages under the projects
- (xix) ensure that while carrying out design works, optimal solution of technical, environmental and social issues is kept in consideration;
- (xx) analyze design options for all aspects of the head-works (if applicable) and main canal rehabilitation and upgrading including cross and head regulators, bridges, measurement structures, escapes, lining and all necessary earthworks as well as evaluating potential construction modalities to be considered with a view to timely and cost effective rehabilitation; divide the project works in to suitable number or contract packages, prepare Bill of Quantities, cost estimate;
- (xxi) explore relevant non-crop interventions (like farmers' training, crop production support interventions, value-addition initiatives, animal husbandry, tree plantation, etc) that may facilitate additional income to the project beneficiaries;

- (xxii) assess procurement, financial management, and O&M capacity of the relevant agencies and propose measures for improvement, if any required;
- (xxiii) prepare / review the Climate Change Risk Assessment study and ensure that design adequately considers the climate change impacts and is stable against factors such as impacts on agriculture water uses, frequent and excessive flows and sedimentation;
- (xxiv) prepare and/ or update PC-I and all necessary appendixes for government's review and approval, including necessary revisions to incorporate comments from the relevant government authorities;
- (xxv) prepare Engineer' Estimate for civil, mechanical and electrical works, packaging of contracts following ADB's Procurement Policy 2017 and Procurement Regulations for Borrowers (2017, as amended from time to time) and their procurement methods;
- (xxvi) prepare tender documents for different contract packages, update/prepare bidding documents incorporating EMP and gender action plan (GAP);
- (xxvii) prepare/ update land acquisition and resettlement plan (LARPs) and environmental impact assessment (EIA) or IEE, environmental management plan (EMP) as required under national laws as well as ADB's Safeguard Policy Statement (SPS) (2009, as amended from time to time) and relevant government laws and regulations;
- (xxviii) prepare TOR for environmental monitoring and management required during construction and implementation of the ensuing projects.
- (xxix) train selected PID staff with a view to strengthening their ability to adequately oversee resettlement activities under each of the ensuing priority projects;
- (xxx) assess social and gender impact and prepare social development and gender action plans (GAP) and participation and communication strategy;
- (xxxi) address specific needs of women farmers for each of the ensuing loans to ensure targeted gender category is expected "effective gender mainstreaming;"
- (xxxii) conduct or revise project benefits, and economic and financial analysis; and document economic, social and environmental rationale to justify the proposed investments;
- (xxxiii) advise on soil reclaiming and develop effective use strategies for optimal use of the limited canal supplies and local groundwater resources with identification of crops suitable for canal command;
- (xxxiv) develop cropping and land use patterns consistent with the proposed integrated development of livestock and crop production together with the Irrigation Specialist, Range Management Specialist, and Livestock Specialist;

- (xxxv) prepare viability of the hydropower generation in Upper Jhelum Canal System and provide necessary provisions of interface where necessary while designing such structures;
- (xxxvi) prepare detailed implementation plans preferably using software such as Primavera P6 or equivalent for monitoring the project activity and generating progress reports using 'earned value' criteria. This shall provide a baseline for all subsequent plan amendments, if needed;
- (xxxvii) carry out necessary rectification, modifications and improvement of documents resultant to review of any or all project documents by the Irrigation Department, allied sister departments of the Government of the Punjab, Government of Pakistan, and financiers/ donors;
- (xxxviii) prepare responses to audit observations and paras in respect of the payments made to consultants and assist the Employer in getting them resolved;
- (xxxix) attend project level meeting with Working Group, ADB Missions as required;
- (xl) prepare all the supporting documents and provide legal support to Employer and attend court / hearing if required;
- (xli) supervise engineering or other studies associated with the project and its components as per instructions of the client;
- (xlii) prepare/ update draft Operational Manuals for all the major structures, main canal and each branch and distributary canal in the command ensuring optimization of water deliveries using the existing or newly constructed;
- (xlili) assist the Client in preparation of quarterly, semiannual and annual progress reports for sending to Donors and government offices; and
- (xliv) Support the PMO and ADB missions, as required.

Specific Scope

Following are specific tasks for the consultant for updating feasibility studies of the identified three priority projects, followed by their detailed designing. For the GTC project, the existing detailed design will be updated:

- (a) **Specific Tasks for Updating Feasibility Studies:** Following are specific tasks for the consultant for updating feasibility studies of the identified priority projects, followed by their detailed designing:

1. **Remodeling and Upgrading of Dera Ghazi Khan Canal System**

Remodeling of D.G Khan Canal System: The consultant will need to work for their independent technical and economic reviews and oversight to ensure improved quality in the updated feasibility studies through a consensus solution based on regime flow analysis that would lead to stable canal geometry.

Rehabilitation and Remodeling of Various Structures: The consultant will review the proposals regarding rehabilitation and remodeling of various water distribution structures, cross drainage works, sediment ejectors, and bridges and finalize recommendations.

Multiple Uses of Water: The consultant will explore the optimal combined use of water for human consumption, as well as high-value crop production using HEISs.

Sustainability: The consultant will need to design the project to ensure sustainability by devising suitable operation and maintenance (O&M) procedures, maximum cost recovery, strong stakeholders participation at all stages, and project design suitable for local conditions and culture.

Climate Change Adaptations: The consultant will incorporate suitable adaptations in project design that will meet the challenges of climate changes.

Due Diligence: The consultant will ensure that the project complies fully with the ADB due diligence guidelines related to environment, involuntary resettlement, and social aspects including gender.

Revision and Updating of Project Design, Costs, and Economic and Financial Analyses: The consultant will develop alternate development plans, including non-crop initiatives (like farmers' training, crop production support interventions, value-addition initiatives, animal husbandry, tree plantation, etc) that may facilitate additional income to the project beneficiaries, with their estimated costs and benefits and select the most suitable alternate in consultation with all stakeholders including PID and ADB. The consultant will prepare the feasibility level design for the selected alternate and revise the economic and financial analysis following relevant ADB Guidelines.

2. **Rehabilitation and Upgrading of Upper Jhelum Canal (UJC) System**

Remodeling of Upper Jhelum Canal: The consultant will work for their independent technical and economic reviews of the existing feasibility study, and oversight to ensure improved quality in the updated feasibility studies through a consensus solution based on regime flow analysis that would lead to stable canal geometry.

Rehabilitation and Remodeling of Various Structures: The consultant will review the proposals regarding rehabilitation and remodeling of various water distribution structures, cross drainage works, sediment ejectors, and bridges and finalize recommendations.

Sustainability: The consultant will need to design the project to ensure sustainability by devising suitable operation and maintenance (O&M) procedures, maximum cost recovery, strong stakeholders participation at all stages, and project design suitable for local conditions and culture.

Climate Change Adaptations: The consultant will incorporate suitable adaptations in project design that will meet the challenges of climate changes.

Due Diligence: The consultant will ensure that the project complies fully with the ADB due diligence guidelines related to environment, involuntary resettlement, and social aspects including gender.

Revision and Updating of Project Design, Costs, and Economic and Financial Analyses: The consultant will develop alternate development plans, including non-crop initiatives (like farmers' training, crop production support interventions, value-addition initiatives, animal husbandry, tree plantation, etc) that may facilitate additional income to the project beneficiaries, with their estimated costs and benefits and select the most suitable option in consultation with all stakeholders including PID and ADB. The consultant will prepare the feasibility level design for the selected alternate, and revise the economic and financial analysis following relevant ADB Guidelines.

3. **Remodeling of R-Q, Q-B & B-S Link Canals:**

Remodeling of Link Canals: The project involves remodeling of Rasool-Qadirabad, Qadirabad-Balloki, and Balloki-Suleimanki link canals. There seems to be differences in the opinion of various experts of PID on the remodeling proposals. Thus, the consultant will need to work for their independent technical and economic reviews and oversight to ensure improved quality in the updated feasibility studies through a consensus solution based on regime flow analysis that would lead to stable canal geometry.

Rehabilitation and Remodeling of Various Structures: The consultant will review the proposals regarding rehabilitation and remodeling of various structures on the link canals and finalize recommendations.

Multiple Uses of Water: The consultant will explore the optimal combined use of water for human consumption, as well as high-value crop production using HEISs.

Value Addition and Value Chain: The consultant will be required to explore the possible value addition activities relevant to the project and promotion of value chain particularly relevant to the products.

Climate Change Adaptations: The consultant will incorporate suitable adaptations in project design that will meet the challenges of climate changes.

Due Diligence: The consultant will ensure that the project complies fully with the ADB due diligence guidelines related to environment, involuntary resettlement, and social aspects including gender.

Revision and Updating of Project Design, Costs, and Economic and Financial Analyses: The consultant will develop alternate development plans with their estimated costs and benefits and select the most suitable alternate in consultation with all stakeholders including PID and ADB. The consultant will prepare the feasibility level design for the selected alternate and revise the economic and financial analysis following relevant ADB Guidelines.

- (b) **Specific Tasks for Updating Detailed Design and Project Readiness Support:** The consultant will develop alternate development plans with their estimated costs and benefits and select the most suitable alternate in consultation with all stakeholders including PID and ADB. The consultant will prepare the feasibility level design for the selected alternate and revise the economic and financial analysis following relevant ADB Guidelines.

4. **Greater Thal Canal (Phase-III) Project:**

Greater Thal Canal (GTC) Project comprising three (3) Phases was taken up by WAPDA. The Project feasibility study for the entire scheme was prepared by the Consultants hired by WAPDA during 1992-94 and detailed design was completed in 2007. Greater Thal Canal Phase-III has been identified as a priority project for updating the detailed design and other project preparation under the ADB's Project Readiness Financing Facility.

Following are specific tasks for the consultant for updating detailed design for the above identified priority project:

- i. plan and execute additional social, agricultural, hydrological, topographical surveys, geotechnical investigations and other such activities along the canal alignment and around structures necessary for updating the detailed design;
- ii. update all relevant technical documents; design parameters & criteria. Check whether the design calculations were correct and appropriate standards were adopted. In case of any disagreement, the Consultants will update the detailed design as per fresh surveys and investigations and revised design calculations;
- iii. plan and execute any additional investigations deemed necessary for any hydraulic or structural aspects to be included in the studies;
- iv. review and update all topographic maps, profile and cross-section surveys required to develop required working drawings of canal reaches and hydraulic structures being rehabilitated. Provide necessary input data for updating the detailed design of the main and branch canals and associated works;
- v. analyze all hydraulic design options for ensuring satisfactory sediment transport and minimizing cost requirements without sacrificing system performance or control required for efficient and equitable distribution of irrigation water;
- vi. develop alternate development plans, including non-crop initiatives (like farmers' training, crop production support interventions, value-addition initiatives, animal husbandry, tree plantation, etc) that may facilitate additional income to the project beneficiaries, with their estimated costs and benefits and select the most suitable option in consultation with all stakeholders including PID and ADB. The consultant will prepare the feasibility level design for the selected alternate, and revise the economic and financial analysis following relevant ADB Guidelines; and
- vii. review all other documents required for project readiness as indicated in section 'C' "Detailed Engineering Designs and Project Readiness Support."

Command Area Development (CAD) Activities: In this context, the consultants will:

- i. prepare inventory of quantity and quality of all available resources including soil types, topography, availability of surface/ groundwater resources, groundwater depths, aquifer quality, depletion trends, recharge rates along with their sources, number of tubewells & density, rainfall pattern, rainwater harvesting potential & its contribution in irrigation, farm sizes, land tenure etc. The resource assessment would also include farming practices, irrigation methods, efficacy of existing agricultural practices, water productivity, cropping patterns & intensities, input use levels, crop yields etc. The consultants will carry out field surveys for ground truthing/ verification of such data gleaned from various documents/ reports, statistical records etc;
- ii. consultants will develop a detailed engineering and revenue Chakbandi of the proposed new outlets/ watercourses;
- iii. suggest suitable farmers' friendly cost sharing arrangements for various packages of interventions for each area to promote adoption of modern technologies e.g. watercourse development, LASER land levelling, drip/ sprinkler irrigation systems, tunnel farming etc. among various categories of farmers after thorough consultation with the farming community and the OFWM wing of Agriculture Department;
- iv. recommend mechanisms and plans for capacity building of farmers as well as training of other stakeholders for each area to ensure provision of technical assistance for successful adoption of proposed interventions;
- v. carry out economic and financial analyses for each of the proposed package/ CAD model and intervention for each area.;
- vi. explore the possibility for development of waste lands through cooperative, corporate or any other such farming mode; and
- vii. consult with the OFWM wing of Agriculture Department and propose a comprehensive implementation strategy for the recommended development options including investment priority, timeframe, institutional setup, stakeholders, roles/ responsibilities.

(c) Detailed Engineering Designs and Project Readiness Support:

- (i) the Consultants shall proceed with the identified priority projects and complete the detailed engineering designs of all structures for the selected alternatives of the project components i.e. main canal, distribution system, crossings of Hill torrents and drainage measures including all electro-mechanical works.

- (ii) prepare cost estimates and PC-I of the Projects as and when required for approval. For the purpose of cost estimating:
 - all unit prices for major quantities of work shall be established by the latest methods. These methods will simulate each construction activity in such a way as to fit it into the available time span in the proposed construction schedule. Construction equipment, crews, materials and other resources would be adjusted to accomplish the work within the required time span. The computations or unit prices shall be supported by detailed sets or financial price with source.
 - indirect cost of construction for all major items should be established separately. Total cost of each construction item shall then be obtained by multiplying the direct cost of construction by a bid factor representing the influence of indirect cost.
- (iii) preparation or cost estimates of the project broken into local and foreign components. These shall include:
 - reasonable breakdown by major items or electro-mechanical and civil works or canal / irrigation network. Price for major civil works and permanent equipment shall be estimated on the basis of internationally advertised open competitive bidding (OCB).
 - environmental Impact Assessment and Resettlement Action Plan with cost estimation.
 - project engineering and management expenses and an adequate allowance of physical contingencies.
 - import duties, taxes and interest during construction (to be assessed separately and not be included in the base cost estimate).
 - preparation or a construction schedule using CPM analysis and schedules for annual construction expenditures, both for local and foreign currency components, throughout the construction period as well as a schedule of annual expenditures for resettlement Action Plan and other items.
 - task shall culminate at the production by the consultants of a design report with the cost estimate to be discussed in PMO, PID, Steering Committee and ADB.
- (iv) preparation of tender drawings with sufficient details for the purpose of international competitive bidding.
- (v) preparation of tender documents (Bidding documents including BOQ, special provisions and technical specifications) in line with FIDIC Conditions of Contract for Construction. The bidding documents shall cover the civil / electro-mechanical works of the project and its components.

- (vi) preparation of construction drawings complete in all respect for all civil, electrical and mechanical works.

Survey and Investigations

- (i) plan and execute additional surveys, geotechnical investigations and other such activities where necessary to provide a basis for both detailed designing and subsequent preparation of construction drawings. The consultants shall hire, with prior approval of the client, any additional services of such other agencies responsible for carrying out the aforesaid surveys, investigations and model studies etc.

4. TEAM COMPOSITION AND QUALIFICATION REQUIREMENTS FOR KEY EXPERTS

- 9. The Consultant will maintain one (01) main office at Lahore for their team members.

Indicative Staffing Requirements for Design Consultants

10. Following matrix represents the client's reflection on the consultant's team composition and indicative estimation of person-months for its team staffing for feasibility review, detailed design, procurement documents, tender and construction drawings and performance of the assignment. The prospective consultants should, however, propose their own breakdown of staffing and level of effort / staff work based on their own experience and evaluation of the proposed services. The consultants should propose a realistic deployment schedule for all positions depending on the work requirements as all positions listed below would have inputs for different durations.

Indicative inputs are 183 person-months of key experts (15 international person-months and 168 person-months national person-months) and 397 person-months of non-key experts as shown in the table below. Person-months of the Key experts and the composition of the Non-key experts and their person-months and assignment schedule will be evaluated as part of work plan and methodology of the services. and consultants' ability to provide all required professionals. The assignment further envisages an additional pool of 30 unallocated person-months of experts under "physical contingencies" to support the implementation of assignment components as and when required. The estimated duration of the consulting services is thirty-six (36) months. The consultants shall follow and deploy the professionals as per the implementation schedule given.

**INDICATIVE STAFFING REQUIREMENTS FOR
CONSULTING SERVICES FOR DETAILED DESIGN**

Sr. #	Position	Qualification	General/ Overall experience (Years)	Job Specific experience (Years)	Indicative Input of Experts (Months)
KEY EXPERTS					
KEY EXPERTS (International)					
1	Water Resources Specialist	B.Sc. Civil Engineering. An additional Master's degree or PhD in Civil / Water Resources / Hydraulic Engineering is preferable and would be rated higher.	20	15 years' professional experience in the planning and design of large scale water resources development projects. Five (05) years of that experience shall have been on large irrigation project and 05 years on major projects in South Asia will be preferred.	10
2	Environmental Specialist	Master's degree in Environmental Sciences/ Environmental Engineering or equivalent	15	10 years' professional experience in conducting environmental assessment ³ of major water sector projects in accordance with environmental guidelines of ADB or similar development partners like the World Bank	03
3	Climate Change Specialist	Master's degree in climate science/ climatology or a closely related discipline	15	10 years' professional experience in, climate change or related water resource issues. Experience in South Asia is preferred.	02
Sub-Total Key Experts (International)					15
KEY EXPERTS (National)					
1	Irrigation and Drainage Management Specialist / Team Leader	B.Sc. Civil Engineering. An additional Master's degree or Ph D in Water Resources / Hydraulic Engineering / Irrigation Engineering is preferable and would be rated higher	20	15 years' professional experience in planning, implementation and management of large scale irrigation and drainage systems including those where conjunctive use is an important aspect. 05 years' of that experience will have been related to large scale irrigation systems in a senior position.	36
2	Lead Design Engineer / Deputy Team Leader	B.Sc. Civil Engineering. An additional Master's degree or PhD in Water Resources / Hydraulic Engineering / Irrigation Engineering is preferable and would be rated higher.	20	15 years' professional experience in design of new and rehabilitation of existing large scale irrigation systems including 05 years' specific experience in design of similar projects in a senior position.	30

³ It includes 'environmental screening'.

Sr. #	Position	Qualification	General/ Overall experience (Years)	Job Specific experience (Years)	Indicative Input of Experts (Months)
3	Senior Hydraulic Engineer	B.Sc. Civil Engineering. An additional Master's degree or PhD in Water Resources / Hydraulic Engineering is preferable and would be rated higher.	15	10 years' professional experience in design of civil works on major hydraulic structures of large water sector projects including 05 years' specific experience in planning and designing of dams.	24
4	Senior Structural Design Engineer	B.Sc. Civil Engineering An additional Master's degree or PhD in Structural Engineering is preferable and would be rated higher.	15	10 years' professional experience in structural design of major infrastructure including 05 years' specific experience in design of new and rehabilitation of barrages, head-works and canal head regulators on major irrigation projects.	15
5	Senior Groundwater / Drainage Engineer	B.Sc. Civil Engineering An additional Master's degree or PhD in civil / hydraulic engineering and/or hydrogeology is preferable and would be rated higher.	15	10 years' professional experience in groundwater utilization and management including 05 years' specific experience in similar position related to alluvial aquifer systems.	12
6	Senior Hydrologist	B. Sc. Civil Engineering. An additional Master's degree or PhD in Water Resources Engineering / Hydrology is preferable and would be rated higher.	15	10 years' professional experience in hydrological analysis/ studies on major streams in the Indus Basin including 05 years' specific experience in similar position on dams.	12
7	Water Management Specialist (WMS) / Agricultural Engineer (AE)	B.Sc. Agriculture Engineering. Master's degree in Agriculture Engineering. / Water Resources Management.	15	10 years' professional experience in water management activities in public/ private sector including 07 years' specific experience in on-farm water management, command area development and irrigated agriculture development projects with demonstrated ability to work with government officials, technical field staff, donors and farmers. In addition, WMS/ AE should have familiarity with the principles and practices of participatory community development, irrigated agriculture and water management related issues besides fluency in spoken and written English.	09
8	Environmental Specialist	Master's degree in Environmental Sciences / Environmental Engineering or equivalent	15	10 years' professional experience in conducting environmental assessment ⁴ of major water resources projects in accordance with GoP and ADB's Environmental Guidelines	12

⁴ It includes 'environmental screening'.

Sr. #	Position	Qualification	General/ Overall experience (Years)	Job Specific experience (Years)	Indicative Input of Experts (Months)
9	Resettlement Specialist	Master's degree in Sociology / Rural Sociology / Social work / Social Sciences or equivalent	15	10 Years' professional experience in activities relating to land acquisition and planning & implementation of resettlement plans on large construction projects including 05 years' specific experience in similar position on large water sector projects in accordance with GoP and ADBs' / World Bank's Social Safeguards Policy Guidelines.	06
10	Procurement Specialist	B. Sc. Civil Engineering.	15	10 years' experience in the procurement of civil works and contract management including 03 years' specific experience in similar position related to procurement under ADB / World Bank Projects using international and national competitive bidding procedures.	06
11	Economist	Master's degree in Project Economics.	15	10 years' professional experience in costing and analyzing the economics of major irrigation investment projects.	06
Sub-Total Key Experts (National)					168
Total Key Experts (International & National)					183
NON-KEY EXPERTS (National)					
1	Irrigation Design Engineers (02 persons) • 1 st . person = 30 month • 2 nd person = 24 month	B.Sc. Civil Engineering. An additional Master's degree in Water Resources/ Irrigation Engineering is preferable and would be rated higher	12	08 years' professional experience in design of irrigation civil works including 05 years' specific experience in design of new and rehabilitation works on major canal systems.	54
2	Hydraulic Design Engineer	B.Sc. Civil Engineering. An additional Master's degree in Hydraulic / Engineering is preferable and would be rated higher.	12	08 years' professional experience in detailed design of the hydraulic aspects of civil works related to irrigation and drainage projects including 05 years' specific experience in design of new and rehabilitation of existing barrages, headworks and canal head regulators.	24
3	Structural Design Engineers (02 persons) • 1 st . person = 20 month • 2 nd person = 16 month	B.Sc. Civil Engineering. An additional Master's degree in Structural Engineering is preferable and would be rated higher.	10	07 years' professional experience in structural design of major infrastructure including 04 years' specific experience in structural design of headworks, barrages, and other hydraulic structures on large canals	36
4	Geotechnical Engineer	B.Sc. Civil Engineering. An additional Master's degree or PhD in Geotechnical Engineering is preferable and would be rated higher.	15	10 years' professional experience in design of geotechnical works for major hydraulic structures including 05 years' specific experience in design of similar works on dams.	12

Sr. #	Position	Qualification	General/ Overall experience (Years)	Job Specific experience (Years)	Indicative Input of Experts (Months)
5	Mechanical Engineer	B. Sc Mechanical Engineering	15	10 years' professional experience in design / fabrication and operation of gates, hoists and mechanical equipment for major irrigation and drainage projects.	09
6	Hydrologist	B. Sc Civil Engineering. An additional Master's degree in Water Resources Engineering/ Hydrology is preferable and would be rated higher.	15	10 years' professional experience in hydrological analysis/ studies on major streams in the Indus Basin including 03 years' specific experience in similar position on dams.	09
7	Geologist	B. Sc. Civil Engineering or M.Sc. in Geology. An additional Master's degree in Water Resources Engineering is preferable and would be rated higher.	15	10 years' professional experience in Planning and supervision of various geological investigation programs in the structural design of head-works, bridges and other hydraulic structures of major streams of the Indus Basin.	06
8	Modelling Expert	B. Sc. Civil Engineering. An additional Master's degree in Civil / Hydraulics Engineering is preferable and would be rated higher.	15	10 years' professional experience in modelling the hydraulic aspects of civil works related to irrigation and drainage projects including 05 years' specific experience in physical modelling of rivers and major irrigation structures.	03
9	Procurement Engineer	B.Sc. Civil Engineering	12	08 years' professional experience in procurement of civil works including 05 year's specific experience in procurement under ADB / World Bank Guidelines using ICB procedures under FIDIC Conditions of Contract for Construction.	12
10	Irrigation Agronomist	Master's/ Ph.D degree in Agronomy/ Agriculture.	15	10 years' professional experience in the relevant field in public/ private sector including 05 years' specific experience in irrigation agronomy and irrigated agriculture development projects. Should have demonstrated ability to work with government officials, technical field staff, donors and farmers. In addition, work experience in related computer tools, good communication skills, fluency in English and satisfactory record of similar consultancies would be preferred.	09
11	Horticulturist/ High Value Agriculture (HVA) Specialist	Master's/ Ph.D degree in Horticulture	10	05 years' professional experience in horticulture related activities with 03 years; specific experience in development of irrigated agriculture and high-value agriculture projects. Work experience in related computer tools, good communication skills, fluency in English and satisfactory	06

Sr. #	Position	Qualification	General/ Overall experience (Years)	Job Specific experience (Years)	Indicative Input of Experts (Months)
				record of similar consultancies would be preferred.	
12	Assistant Agriculture Engineer	Bachelor's degree in Agriculture Engineering	10	05 years' professional experience engineering in on-farm water management projects. Work experience in related computer tools, good communication skills, fluency in English and satisfactory record of similar consultancies would be preferred.	09
13	High Efficiency Irrigation Systems Specialist	B. Sc. Civil Engineering. An additional Master's degree in Water Management Systems is preferable and would be rated higher.	15	10 years' professional experience in planning, design and setting up of high efficiency irrigation systems.	02
14	Range Management Specialist	B.Sc. Agriculture / Forestry. An additional Master's degree in Forestry is preferable and would be rated higher.	15	10 years' professional experience in planning, design, and management of range lands.	02
15	Livestock Development Specialist	Basic degree in Veterinary Sciences / Animal Husbandry or Doctor of Veterinary Medicine (DVM) An additional Master's degree in Livestock Management is preferable and would be rated higher.	15	10 years' professional experience in planning, design, and management of livestock.	03
16	Climate Change Specialist	Graduate degree, preferably post graduate degree, in civil engineering, hydrology, climate science or a closely related discipline	10	05 years' professional experience in carrying out climate risk and vulnerability assessment of irrigated agricultural project together with experience of climate change adaptation measures for such projects.	02
17	GIS Expert	Master's degree in GIS / Space Science	15	10 years' professional experience in GIS database development of Water Resources Systems.	04
18	Junior Sociologist	Master's degree in Sociology / Rural Sociology / Social work/ Social Sciences or equivalent	07	05 years' professional experience in developing social studies and plans for large-scale water sector projects in Pakistan	12
19	Junior Resettlement Expert	Master's degree in Sociology / Rural Sociology / Social work / Social Sciences or equivalent	07	05 years' professional experience in planning and implementing resettlement programs associated with irrigation infrastructure projects.	09

Sr. #	Position	Qualification	General/ Overall experience (Years)	Job Specific experience (Years)	Indicative Input of Experts (Months)
20	Social Development and Gender Expert (preferably female) ⁵	Master's degree in Sociology/ Anthropology/ Gender & Women Studies/ Economics or equivalent	07	04 years' professional experience in working with development organizations, communities (rural areas) and government line departments and implementation of social development programs and gender action plan (GAP) on various projects including 02 years' specific experience in similar position on various projects with multiple donors.	03
21	Survey Engineer	B.Sc. Civil Engineering	07	05 years' professional experience in surveying of civil works preferably related to irrigation and drainage projects.	06
22	Junior Engineers (3-4 No.)	B.Sc. Civil / Mechanical / Electrical Engineering	05	03 years' professional experience in engineering design projects.	75
Sub-Total:					307
PMO Support Staff*					
1	Project Coordinator	B.Sc. Civil Engineering	12	08 years' professional experience in the relevant field.	36
2	Senior Engineer Procurement	B.Sc. degree in Civil/ Mech. Engineering	12	10 years' experience in the procurement of civil works and contract management. Also 5 years' specific experience related to procurement of works & consulting services under ADB/ World Bank/ JBIC funded Projects with 2 years' experience in similar position on projects using ICB procedures under FIDIC Conditions of Contract for Construction.	18
3	Safeguard Specialist	Master's degree in Sociology / Social Work / Social Sciences	12	10 years' professional experience in social development action plan (SDAP) activities and planning/implementation resettlement plans on large construction projects including 05 years' experience in similar position on large water sector projects in accordance with GoP and ADBs' / World Bank's Social Safeguards Policy Guidelines.	18
4	Agronomist	Master's/ Ph.D degree in Agronomy/ Agriculture.	12	10 years' professional experience in the relevant field in public/ private sector including 05 years' specific experience in irrigation agronomy and irrigated	18

⁵ Taken into consideration the country gender and cultural context, as well as the specific tasks under the expert's TORs, a consulting firm is encouraged to engage a female gender specialist for this assignment.

Sr. #	Position	Qualification	General/ Overall experience (Years)	Job Specific experience (Years)	Indicative Input of Experts (Months)
				agriculture development projects. Should have demonstrated ability to work with government officials, technical field staff, donors and farmers.	
	Sub-Total (PMO Support Staff)				90
	UN-ALLOCATED PERSON-MONTHS				30
	GRAND TOTAL (EXPERTS)				610

Summary of the Consulting Services Required

Expertise	person-months
Key Experts (International)	15
Key Experts (National)	168
Non-key Experts (National)	307
PMO Support Staff	90
Unallocated	30
Grant Total Experts	610

* PMO Support Staff will be hired for Client's Office in consultation with Head/ Project Director, PMO. These Experts will be a part of the Consultants Team but will work in Client's office to support the client.

Notes:

- (i) *The above-mentioned person-months include Consultant's professional input only.*
- (ii) *The unallocated 30 person-months of experts to be paid under physical contingencies to support the implementation of assignment components as and when required.*
- (iii) *The above positions do not include miscellaneous contract / support staff (non-technical, semi-technical and technical input) like office manager, accounts manager, accountant, surveyors, quantity surveyors, inspectors, social enumerators (male and female), auto-CAD operators, draftsmen, guards, drivers and office boys etc. They should be included in consultant's estimated reimbursable expenses items (see the item [iv] below). They should not be included in costs and person-months of experts.*
- (iv) *All support staff in the Design Office will be provided by the Consultants who are required to include cost of such support staff in the Reimbursable Expenses items.*

11. In the evaluation of technical proposals, the Key experts will be evaluated individually. The Consultants should submit CVs for all positions of Key experts Expert (only one CV for each expert position and comprising not more than five pages printed on one side of A4 size

paper in font size of 11). Any TBN position in the key experts will be marked zero. The CV template of ADB's Standard Request for Proposals should be used to prepare these CVs. The Consultants shall bear full responsibility for correctness of the submitted CVs.

12. The Non-key personnel will be evaluated collectively as a team for adequacy of the nominated staff and consultants' ability to provide all required staffing. Therefore, Consultants are required to provide short CVs of all nominated staff against non-key positions. The CVs should contain information, in sufficient detail, about position title, name, date of birth, citizenship, CNIC number, education, PEC registration, professional memberships, trainings, employment record and work experience in the relevant assignments (One short CV shall not comprise more than three pages printed on one side of A4 size paper in font size of 11). The Consultants shall bear full responsibility for correctness of the submitted CVs.

JOB DESCRIPTION OF CONSULTANTS' KEY EXPERTS⁶

I. INTERNATIONAL EXPERTS

Indicative tasks of each experts are indicated below. Detailed tasks of each experts will be developed by the consultants to meet with the requirements given under scope of work and will be described in their technical proposals.

1. Water Resources Specialist (International: 10 person-months indicative):
Responsibilities of the Water Resources Specialist will include but not limited to the following:

- i. manage field surveys, investigations, and physical and mathematical models, if any, requires for feasibility studies and detailed designs;
- ii. timely delivery and quality control of all required outputs including feasibility studies for new designs, rehabilitation and upgrading of the existing priority projects;
- iii. develop alternate plans for all priority projects and selecting optimal plans keeping in view the water availability (quantity and schedule), local climatic and social conditions, and groundwater quality and depth. The plan should consider long-term water storage with integrated livestock farming, domestic water supply, and crop production with high efficiency irrigation systems (HEISs) particularly in areas to be served with flood water supplies only. Assess the technical and physical support required (like veterinary and range management services) together with financial resources during the O&M period;
- iv. provide coordination and oversight to ensure that monitoring and evaluation (M&E), resettlement, environmental, agricultural, on-farm water management, groundwater resource management and institutional aspects of the studies appropriately address the situations identified on the ground;

⁶ Responsibilities of individual specialists should be read in conjunction with the capsule TOR for the undertaking as a whole. Some specialists will be involved in both the feasibility level studies and detailed design while others will provide inputs solely for planning or for detailed design.

- v. work with the project team to develop innovative quality assurance mechanisms to ensure institutional reforms remain the key element driving all project activities; and
- vi. provide his input regarding spate irrigation for updating the feasibility studies and preparation of detailed design for hill torrent projects using his international experience.

2. Environmental Specialist (International: 03 person-months indicative):

Responsibilities of the Environmental Specialist will include but not limited to the following:

- i. assess and compare PID and the Punjab and Pakistan Governments' environmental legislation and frameworks with those of ADB and best international practice to identify gaps, differences or conflicts and recommend modifications and/or mechanisms to promote compatibility;
- ii. conduct initial environmental assessment and determine categorization for the projects and for individual components and where applicable individual distributary commands as appropriate to comply with ADB's environmental assessment guidelines;
- iii. based on determined categorization, prepare initial environment examinations (IEEs) or environmental impact assessments (EIAs) studies including environmental management plans (EMPs)⁷ compliant with ADB guidelines;
- iv. assess the capacity of PMO/PID staff for environmental assessment and implementation of EMPs, and assess the training requirements for capacity building;
- v. assess the environmental capacity of the Punjab and Pakistan government agencies involved in vetting and approving the environmental assessments and develop environmental assessment and review procedures and prepare detailed arrangements, agreeable to all parties, which may be used throughout the program to facilitate review of documents related to the various projects; and
- vi. identify environmental issues related to the sector or any of the ensuing projects requiring loan covenants to ensure subsequent appropriate resource management.

3. Climate Change Specialist (International: 02 person-months indicative):

Responsibilities of the Climate Change Specialist will include but not limited to the following:

- i. assess and report on the climate risks to the beneficiaries, structure, and performance of the Projects and, in collaboration with the project readiness financing team, assess, recommend, and report opportunities to reduce these risks through adaptation interventions;
- ii. prepare and appraise feasibility studies for the proposed projects and will provide detailed inputs to these feasibility studies, and more general, area-based

⁷ EMPs should include concrete mitigation measures specific to the project context, monitoring and training plan.

assessments to inform future, potential projects or the detailed designs of existing projects;

- iii. carry out the climate risk and vulnerability assessment (CRVA) to assess the expected changes in the pattern and level of precipitation, groundwater, river flows, and flood risks for each project; and
- iv. undertake more detailed assessment and/or modeling at site level for each project that will be studied under the Project Readiness Financing. These site-specific assessments will inform these project designs, including (a) selection of target beneficiaries; (b) offtake points and flood defenses; (c) canal alignment and distribution options; (d) alternative sources; and (e) command area development.

II. NATIONAL KEY EXPERTS

National experts can be grouped in two categories i.e. those who will support the international experts of their fields constitute the first category while those who have no international experts of their respective fields constitute the second category. National experts of the first category will assist and support the relevant principal international experts and while working under the supervision of the Team Leader will receive technical guidance directly from the relevant international expert. In each case, they will assist in carrying out all aspects of the relevant international expert' TOR and in his/her absence accept full responsibility for all aspects of his/her TOR. Therefore, detailed individual terms of reference are not separately prepared for these individuals. However, expected qualifications and detailed TOR of the national experts of the second category i.e. experts with no respective international experts, are given here.

1. Irrigation and Drainage Management Specialist / Team Leader (National: 36 person-months indicative) Responsibilities of the Irrigation and Drainage Management Specialist / Team Leader will include but not limited to the following:

- i. provide overall direction to all specialists making up the consulting team and appropriately group individuals into work units responsible for a particular feasibility study and/or detailed design undertaking;
- ii. manage relationships with Project Management Office (PMO), Punjab Irrigation Department (PID), the Punjab Government, Review Panel, and the Asian Development Bank (ADB) as well as with other stakeholders including farmers;
- iii. prepare detailed, time bound work plans for the design, and tendering of all civil works contract packages envisaged for the works assigning various team members to each key task;
- iv. provide technical support and guidance on design and tendering on all aspects of head regulators; canals; distribution system and associated facilities for livestock watering, domestic water supply, and HEIS for high value crops; and other relevant aspects;
- v. provide coordination and oversight to ensure that monitoring and evaluation (M&E), resettlement, environmental, agricultural, on-farm water management,

groundwater resource management, and institutional aspects of the studies appropriately address the situations identified on the ground;

- vi. monitor the progress of all planning and design work ensuring that deadlines relating to delivery dates are met;
- vii. review in detail both the design and construction work underway on the main, branch, distributary, and minor canals with a view to adoption of best practice innovations;
- viii. prepare comprehensive plans and feasibility level designs for rehabilitating and upgrading main, branch, distributary and minor canals including all associated control structures and other required supporting infrastructure including cross drainage, emergency escapes, bridges etc for the commands of the project canals;
- ix. confirm both functional and structural requirements of main canal and distribution system structures in consultation with the hydraulic and structural specialist;
- x. review and recommend any changes in supply arrangements from the main to distributary canals and from the distributary and minor canals to watercourses to improve either efficiency or equity of distribution;
- xi. work with the agriculturist in making adequate provision for the water requirements of higher value crops which may be introduced into the cropping pattern in the future;
- xii. provide his input regarding spate irrigation for updating the feasibility studies and preparation of detailed design for hill torrent projects using his national experience and under the guidance of International Spate Irrigation Specialist; and
- xiii. attend all meetings, provide feedback and backstopping on different aspects of spate irrigation and integrated resources management approach.

2. Lead Design Engineer / Deputy Team Leader (National: 30 person-months indicative): Responsibilities of the Lead Design Engineer / Deputy Team Leader will include but not limited to the following:

- i. assist the Team Leader in providing, and in his/ her absence, provide overall direction to all specialists making up the consulting team and appropriately group individuals into work units responsible for a particular feasibility study and/ or detailed design undertaking;
- ii. assume overall responsibility for management and supervision of the design teams for design of new and rehabilitation and upgrading work and timely consultation on all design considerations with PMO, PID, Review Panel and ADB;

- iii. provide technical support and guidance in all aspects of the design efforts including hydrology, flood routing, physical and mathematical hydraulic modeling, canal design, sediment transport, mechanical considerations, etc;
- iv. organize and supervise all topographic, profile, and cross-section surveys required to provide necessary input data for detailed design of the head regulators; main; branch; distributary and minor canals and associated facilities for livestock watering, domestic water supply, and HEIS for high value crops; and associated works;
- v. undertake the design of new and rehabilitation and upgrading or replacement works including but not limited to (a) head regulators, cross regulator and distributary head regulator replacement/rehabilitation for surface irrigation systems, (b) main, branch, distributary and minor canal sectioning, grading and rerouting if required, (c) upgrading and/or replacement of existing water control and bifurcation structure and provision of additional structures as required, (d) cross canal structures such as inverted siphons, aqueducts, etc, (e) required bridges and culverts, (f) mogas (watercourse outlets) as appropriate, (g) aqueducts, (h) escape facilities and associated channels, and (i) associated flood and erosion control measures; and
- vi. ensure that during designing of all structures and features of a repetitive nature, standard designs, pre-approved by the Team Leader and PMO should be used as appropriate to minimize duplicity of design inputs

3. Senior Hydraulics Engineer (National: 24 person-months indicative):
Responsibilities of the Senior Hydraulics Engineer will include but not limited to the following:

- i. organize and coordinate topographic surveys and any other investigations required to provide necessary input data for detailed design;
- ii. work in estimating the design water levels at all points of interest for flood flows of differing return intervals and during normal operation;
- iii. use mathematical modeling results as appropriate to refine both design proposals and operating rules for each point of interest by simulating the effects of varying design parameters;
- iv. analyze hydraulic design options for all points of interest in order to come up with cost effective rehabilitation;
- v. coordinate and supervise detailed design of all hydraulic aspects of the rehabilitation works including preparation of relevant construction drawings and specifications as well as contributing as required to the preparation of the final tender documents;
- vi. undertake the design of new and rehabilitation and upgrading or replacement works of existing facilities;
- vii. design the large and deep long-term water storage areas to store flood flows for integrated development including livestock farming, domestic water supply, and crop production with HEISs;

- viii. ensure that in the design of all structures and features of a repetitive nature, standard designs, pre-approved by the Team Leader and PMO should be used as appropriate to minimize duplicity of design inputs; and
- ix. analyze all hydraulic design options for cross regulators, drop structures, measurement structures, road bridges, distributary and minor head regulators, and lined reaches ensuring satisfactory sediment transport and minimizing cost requirements without sacrificing system performance or control required for efficient and equitable distribution of irrigation water throughout the command areas.

4. Senior Structural Design Engineer (National: 15 person-months indicative):

Responsibilities of the Senior Structural Design Engineer will include but not limited to the following:

- i. organize and undertake a critical examination targeted to establishing the overall structural and geotechnical (foundation) integrity of various sites where new structures are to be constructed or existing structures need to be rehabilitated and upgraded, identifying all remedial works required;
- ii. organize and coordinate all investigations deemed necessary for structural aspects of all features to be included in the rehabilitation and upgrading package for each project structure;
- iii. analyze structural design options for all features to be constructed/rehabilitated with a view to cost-effective, but sustainable rehabilitation;
- iv. coordinate, supervise and undertake preparation of detailed structural design, bills of quantities, and technical specifications for all required new and rehabilitation works identified requiring structural input and treatment, and contribute as required to the preparation of the final tender documents;
- v. analyze structural design options for all project works including cross regulators, distributary and minor canal head regulators, escapes, duck-bill weirs and road bridges with a view to be cost-effective, but sustainable rehabilitation; and
- vi. coordinate, supervise and undertake preparation of detailed structural design, bills of quantities and technical specifications for cross regulators, falls, distributary and minor canal head regulators, escapes, siphons, aqueducts, duck-bill weirs, moghas, and road and foot bridges as well as any other features identified requiring structural input and treatment and contribute as required to preparation of the final tender documents.

5. Senior Groundwater/ Drainage Engineer (National: 12 person-months indicative):

Responsibilities of the Senior Groundwater / Drainage Engineer will include but not limited to the following:

- i. review all relevant studies on groundwater and drainage in the project canal commands and surrounding areas with regard to sources, recharge quantity,

quality, and all aquifer characteristics require to satisfactorily project safe aquifer yields;

- ii. review and investigate each of the canal commands in question with regard to salinization and sodification of project area soils and assess the need for conjunctive use of surface water if groundwater of marginal quality is to be used for irrigation purposes;
- iii. review prior groundwater monitoring activities which establish the number and location of existing tube-wells in the command areas;
- iv. develop, for each of the project areas, a program of enhanced and regularized monitoring of groundwater levels and quality to serve as a data base for development of a finite difference groundwater model to serve as a tool for groundwater management in the command area; and
- v. identify and cost up, for each of the commands, for its respective required improvements in additions to the surface water drainage system to complement irrigation rehabilitation and upgrading.

6. Senior Hydrologist (National: 12 person-months indicative): Responsibilities of the Senior Hydrologist will include but not limited to the following:

- i. establish updated flood frequency analyses of the relevant river sites reflecting all recent upstream development at both the feasibility and detailed design degrees of refinement;
- ii. evaluate the effect of the increased extent of flood levees and embankments along the rivers and the resulting confinement of flow area on the historic flood of record and the flood distribution regime at appropriate sites in the project area; and
- iii. establish flood frequency analyses for all cross-drainage facilities related to the project facilities as directed by the Irrigation Planning and Design Engineers.

7. Water Management Specialist (WMS) / Agricultural Engineer (AE) (National: 9 person-months indicative): Responsibilities of the Water Management Specialist (WMS) / Agricultural Engineer (AE) will include but not limited to the following:

- i. analyse the potential of available water resources for their irrigated agriculture and command area development;
- ii. identify successful models adopted for development of waste lands for irrigated agriculture in neighboring/ other countries under similar conditions;
- iii. tailor the identified package for various categories/ combinations of available resources in terms of farmers, soils, and water categories for development of irrigated agriculture in various parts of these areas;
- iv. scrutinize the most suitable strategies replicable in the project areas for development of irrigated agriculture;
- v. work closely with the Economist, Irrigation Agronomist, Sociologist and other experts for recommending the technically feasible, economically viable, socially

- acceptable, and environmentally sustainable packages for each zone/area/region;
- vi. suggest suitable farmers' friendly cost sharing arrangements for various packages of interventions for each area in coordination with concerned experts to promote adoption of modern technologies e.g. watercourse development, LASER land leveling, drip/ sprinkler irrigation systems, tunnel farming etc. among various categories of farmers;
 - vii. provide support in exploring the possibility for development of waste lands through cooperative, corporate or any other such farming mode;
 - viii. recommend mechanisms and plans for capacity building of farmers as well as training of other stakeholders for each area to ensure provision of technical assistance for successful adoption of proposed interventions; and
 - ix. propose a comprehensive implementation strategy for the recommended development options separately for each area including investment priority, timeframe, institutional setup, stakeholders, roles/ responsibilities, monitoring etc. The description should include all necessary information subsequently required for projects formulation.

8. Environmental Specialist (National: 12 person-months indicative): The Environmental Specialist will assist and support the relevant principal international specialists and while working under the supervision of the Team Leader will receive technical guidance directly from the relevant international specialist. In each case, the specialist will assist in carrying out all aspects of the relevant international specialists' TOR and in his / her absence accept full responsibility for all aspects of his / her TOR. The specialist will assist the international environment specialist in screening and categorizing, identifying gaps; updating environmental assessments; obtaining necessary clearance and permits domestically; carrying local disclosure and public consultation; and following national and local applicable regulations and standards.

9. Resettlement Specialist (National: 06 person-months indicative): Responsibilities of the Resettlement Specialist will include but not limited to the following:

- i. assess all potential; resettlement impacts from the range of interventions proposed for the priority projects within the umbrella of ADB's resettlement policy;
- ii. prepare a resettlement framework consistent with ADB guidelines for each priority project;
- iii. prepare resettlement plans as required in collaboration with Resettlement Unit established in the PMO and relevant PID staff;
- iv. develop detailed implementation arrangements to carry out resettlement activities under all projects and assess the capacity within PMO/PID and other relevant agencies with respect to resettlement and prepare detailed capacity development programs for resettlement activities to be carried out under the projects;

- v. assist PID and PMO staff in complying with ADBs Guidelines for Involuntary Resettlement for those cases where resettlement or temporary disruption of production cannot be avoided;
- vi. in such cases a resettlement plan, in accordance with the existing resettlement framework will be prepared for implementation by PID; and
- vii. review PID, Government of Punjab, and Government of Pakistan policies and practice relevant to resettlement make recommendations for strengthening these and if necessary provide draft guidelines for Government's consideration.

10. Procurement Specialist (National: 06 person-months indicative): Responsibilities of the Procurement Specialist will include but not limited to the following:

- i. review detailed procurement plans and packages and determine realistic time bound schedules for procurement, including parallel and sequential steps for procurement of civil works from initial steps to the delivery of the services under the contracts;
- ii. review the prequalification criteria, notices of pre-qualification and prequalification documents and conduct the prequalification of international contractors in accordance with both PID procedures and ADB guidelines;
- iii. review and update international tender documents for the new and rehabilitation and upgrading of project works in FIDIC format agreeable to PMO, PID and ADB;
- iv. documents to be prepared under (iii) above will include (a) invitation to bid, (b) instructions to bidders, (c) form of bid, (d) form of contract, (e) special and general conditions of contract, (f) drawings and specifications, (g) bill of quantities, (h) schedule of completion, and (i) all necessary addenda;
- v. advise the committee established for evaluation regarding bid opening and the technicalities of the evaluation process and ADB's guidelines and requirements pertaining thereto; and
- vi. advise on preparation of the summary of evaluation and recommendation for award.

11. Economist (National: 06 person-months indicative): Responsibilities of the Economist will include but not limited to the following:

- i. work performing financial and economic analysis for preparation of PC-I;
- ii. estimate the cost and cost benefit, and carry out a financial and economic analysis in accordance with ADB guidelines for financial and economic analysis;
- iii. support the effort to assess farmers' willingness to pay for proposed increases in water tariffs; and conduct affordability analysis in consultation with the social development specialists;
- iv. conduct economic analysis of the project in accordance with ADB's Guidelines for the Economic Analysis of Projects, covering all areas in ADB's Key Areas of Economic Analysis of Projects—Overall (2003), i.e., (a) macroeconomic context

assessment, (b) sector context assessment, (c) demand analysis, (d) economic rationale, (e) least-cost analysis, (f) cost–benefit analysis, (g) financial and institutional sustainability assessment, (h) distribution analysis, and (i) sensitivity and risk analysis;

- v. investigate particularly the impact of the project on poor and vulnerable persons and households in the distribution analysis as one area of the economic analysis following ADB's Guidelines for the Economic Analysis of Projects and the Handbook for Integrating Poverty Impact Assessment in the Economic Analysis of Projects; and
- vi. prepare cost estimate, financing plan and economic and financial analyses for each project.

III. NATIONAL NON-KEY SPECIALISTS

1. Irrigation Design Engineer (02 persons) National: 54 person-months (1st person: 30 months; 2nd person: 24 months indicative): Responsibilities of the Irrigation Design Engineers will include but not limited to the following:

- i. review in detail both the design and construction work underway on the main, branch, distributary, and minor canals with a view to adoption of best practice innovations;
- ii. promote the use of HEIS particularly in the D G Khan hill torrents command area for growing high value crops;
- iii. design and associated facilities for livestock watering, domestic water supply, and HEIS for growing high value crops wherever required and particularly D G Khan hill torrents area,
- iv. prepare comprehensive plans and feasibility level designs for rehabilitating and upgrading main, branch, distributary and minor canals including all associated control structures and other required supporting infrastructure including cross drainage, emergency escapes, bridges etc. for the commands of the project canals;
- v. confirm both functional and structural requirements of main canal and distribution system structures in consultation with the Hydraulic and Structural Specialists,
- vi. develop effective conjunctive use strategies for optimal use of the limited canal supplies and local groundwater resources in consultation with the Groundwater Specialists and Agriculturist;
- vii. ensure that adequate flow measurement sites are provided throughout the system to facilitate both system management and monitoring of system performance; and
- viii. develop relevant operation and maintenance (O&M) strategies for the farmers relative to the distributary and minor canals and for PID relative to main canals and barrages under the projects.

2. Hydraulic Design Engineer (National: 24 person-months): Responsibilities of the Hydraulic Design Engineer will include but not limited to the following:

- i. organize and coordinate topographic surveys and any other investigations required to provide necessary input data for detailed design;
- ii. analyze hydraulic design options for all points of interest in order to come up with cost effective rehabilitation;
- iii. coordinate and supervise detailed design of all hydraulic aspects of the rehabilitation works including preparation of relevant construction drawings and specifications as well as contributing as required to the preparation of the final tender documents;
- iv. draft relevant portions of the Operational Manuals for the projects with emphasis on operating rules based upon water level observations, available flood prediction information and the irrigation demand on the project systems served;
- v. undertake the design of new and rehabilitation and upgrading or replacement works of existing facilities including but not limited to (a) cross regulators and distributary head regulators, (b) main canal sectioning, grading and rerouting if required, distributary and minor canal sectioning, grading and rerouting, (c) upgrading and/or replacement of existing water control and bifurcation structures and provision of additional structures as required, (d) cross canal structures such as inverted siphons, aqueducts, etc, (e) required bridges and culverts, (f) moghas (watercourse outlets) as appropriate, (g) escape facilities and associated channels, and (h) associated flood and erosion control measures;
- vi. ensure designing the conveyance and distribution system including the canals, control structures and all associated works in accordance with accepted fundamentals of irrigation science, hydraulics, soil mechanics and structural engineering;
- vii. in the design of all structures and features of a repetitive nature, standard designs, pre-approved by the Team Leader and PMO should be used as appropriate to minimize duplicity of design inputs;
- viii. analyze all hydraulic design options for cross regulators, drop structures, measurement structures, road bridges, distributary and minor head regulators, and lined reaches ensuring satisfactory sediment transport and minimizing cost requirements without sacrificing system performance or control required for efficient and equitable distribution of irrigation water throughout the command areas;
- ix. draft relevant portions of the Operation Manuals for the project facilities ensuring optimization of water deliveries.

3. Structural Design Engineer (02 persons) National: 36 person-months (1st person: 20 months; 2nd person: 16 months indicative): Responsibilities of the Structural Design Engineers will include but not limited to the following:

- i. organize and undertake a critical examination targeted to establishing the overall structural and geotechnical (foundation) integrity of various sites where new structures are to be constructed or existing structures need to be rehabilitated and upgraded, identifying all remedial works required;
- ii. analyze structural design options for all features to be constructed/rehabilitated with a view to cost-effective, but sustainable rehabilitation;
- iii. coordinate, supervise and undertake preparation of detailed structural design, bills of quantities, and technical specifications for all required new and rehabilitation works identified requiring structural input and treatment, and contribute as required to the preparation of the final tender documents;
- iv. assist in drafting relevant portions of the Operational Manual with emphasis on procedures/practices to ensure the long-term structural integrity of the structure/complex;
- v. organize and undertake a critical examination targeted to establish the overall structural integrity of major structures to be constructed and/or rehabilitated identifying all remedial works required;
- vi. analyze structural design options for all project works including cross regulators, distributary and minor canal head regulators, escapes, duck-bill weirs and road bridges with a view to be cost-effective, but sustainable rehabilitation; and
- vii. coordinate, supervise, and undertake preparation of detailed structural design, bills of quantities, and technical specifications for cross regulators, falls, distributary and minor canal head regulators, escapes, siphons, aqueducts, duck-bill weirs, moghas, and road and foot bridges as well as any other features identified requiring structural input and treatment and contribute as required to preparation of the final tender documents.

4. Geotechnical Engineer (National: 12 person-months indicative): Responsibilities of the Geotechnical Engineer will include but not limited to the following:

- i. responsible for all geotechnical investigation at site and provide data with recommendations to designs;
- ii. review the capacity of soils for designing of structures foundations and identify any remedial foundation stabilization work to be included in the packages of works for new construction, rehabilitation, and upgrading;
- iii. review of design considerations relating to soils and materials engineering;
- iv. locate appropriate sites for materials to be used;
- v. formulate plans for and carry out detailed foundation investigations for the project facilities;

- vi. supervise the work of the sub-contracted drilling, sampling and testing services to ensure compliance with best geotechnical practice; and
- vii. prepare geotechnical and material reports.

5. Mechanical Engineer (National: 09 person-months indicative): Responsibilities of the Mechanical Engineer will include but not limited to the following:

- i. organize, coordinate and carry out a detailed inspection of all gates as well associated head regulator gates of the project facilities to be constructed/rehabilitated;
- ii. prepare detailed designs including drawings, specifications and costs for all remedial measures required for gate rehabilitation works;
- iii. prepare feasibility-level and detailed designs and estimate bills of quantities for the mechanical and electrical works;
- iv. coordinate and supervise detailed design of all mechanical and electrical aspects of the new and rehabilitation works including preparation of relevant construction drawings and specifications as well as contributing as required to the preparation of the final tender documents; and
- v. draft relevant portions of the Operational Manual for the proposed mechanical and electrical facilities with particular emphasis on O&M of the gates and associated hoisting equipment.

6. Hydrologist (National: 09 person-months indicative): Responsibilities of the Hydrologist will include but not limited to the following:

- i. establish updated flood frequency analyses of the relevant river sites reflecting all recent upstream development at both the feasibility and detailed design degrees of refinement;
- ii. evaluate the effect of the increased extent of flood levees and embankments along the rivers and the resulting confinement of flow area on the historic flood of record and the flood distribution regime at appropriate sites in the project area;
- iii. using all available data, simulations and comparisons with like situations in other river basins in South Asia, update and/or prepare a detailed and refined flood frequency analysis at each barrage site relevant to the project including comprehensive hydrographs of flood events for all return frequencies required by the principal hydraulic engineer in planning and designing the rehabilitation and upgrading of the project facilities; and
- iv. establish flood frequency analyses for all cross drainage facilities related to the project facilities as directed by the irrigation planning and design engineers.

7. Geologist (National: 6 person-months indicative): Responsibilities of the Geologist will include but not limited to the following:

- i investigating the structure and evaluation of the earth and its natural resources;
- ii surveying and mapping geologically promising sites;
- iii collecting and recording samples and data from test sites;
- iv analyzing geological data using specialist computer applications; and
- v ascertaining extraction risks;

8. Modelling Expert (National: 03 person-months indicative): Responsibilities of the Modelling Expert will include but not limited to the following:

- i. identify together with the Team Leader and Irrigation Engineers, river reaches and barrage intakes/hydraulic structure, for which modelling would be desirable;
- ii. coordinate with the survey team and sediment collection team for collection of topographic, river bed, and other data required for physical model;
- iii. collect the data on river flow and its variation over the year, and the design flow the barrage/intake structure and its variation over the year;
- iv. select a suitable facility where the model would be constructed and negotiate model construction arrangements and schedule and associated cost; and
- v. supervise the running of the model and collection of data for various scenarios that would facilitate design of the new or remodeling of existing facilities.

9. Procurement Engineer (National: 12 person-months indicative): Responsibilities of the Procurement Engineer will include but not limited to the following:

- i. prepare detailed procurement plans and packages and prepare realistic time bound schedules for procurement, including parallel and sequential steps for procurement of civil works from initial steps to the delivery of the services under the contracts;
- ii. develop, in consultation with PMO, the prequalification criteria, prepare notices of pre-qualification and prequalification documents and conduct the prequalification of international contractors in accordance with both PID procedures and ADB guidelines;
- iii. under the direction of the Team Leader/Design Engineer and using input from various specialists on the team, prepare the international tender documents for the new and rehabilitation and upgrading of project works in FIDIC format agreeable to PMO, PID and ADB;
- iv. The documents to be prepared under (iii) above will include (a) invitation to bid, (b) instructions to bidders, (c) form of bid, (d) form of contract, (e) special and general conditions of contract, (f) drawings and specifications, (g) bill of quantities, (h) schedule of completion, and (i) all necessary addenda;

- v. invite the pre-qualified bidders to submit bids and advise the committee established for evaluation regarding bid opening and the technicalities of the evaluation process and ADB's guidelines and requirements pertaining thereto; and
- vi. advise on preparation of the summary of evaluation and recommendation for award.

10. Irrigation Agronomist (National: 9 person-months indicative): Responsibilities of the Irrigation Agronomist will include but not limited to the following:

- i assess the available resources of each area in terms of agronomic aspects including irrigation methods, efficacy of existing agricultural practices, irrigation requirements, water productivity, cropping patterns & intensities, input use levels, crop yields etc;
- ii address issues and suggest solutions to the problems related to crop production as confronted by the farmers for bringing the wastelands under cultivation;
- iii Identify and recommend water efficient crop varieties based on soil and climatic conditions for each area/ zone;
- iv estimate crop water requirements (CWR) by using climatic data (rainfall, sunshine, humidity, wind speed, temperature etc.);
- v develop guidelines/ manual for irrigation and fertigation schedules to meet input requirements of proposed crops in each area;
- vi prepare cropping patterns based on the water availability for sustainability of irrigated agriculture in each area;
- vii develop crop budgets/ farm budgets under existing and proposed conditions for identifying economically viable interventions and cropping patterns for each area;
- viii recommend plans/packages for successful crop production including land preparation, planting, irrigation scheduling, inter-culture, fertigation, harvesting, processing and marketing, etc. under modern crop production technologies particularly high efficiency irrigation systems; and
- ix identify requisite agronomic support to be provided to the farmers for successful adoption of proposed interventions to enhance crop & water productivities for each area; and
- x provide his input regarding spate irrigation for updating the feasibility studies and preparation of hill torrent projects using his national experience and under the guidance of International Spate Irrigation Specialist.

11. Horticulturist / High Value Agriculture (HV) Specialist (National: 6 person-months indicative): Responsibilities of the Horticulturist / High Value Agriculture (HVA) Specialist will include but not limited to the following:

- i review the existing information about horticulture/ HVA and its potential in various areas;
- ii carry out baseline survey to determine status of horticultural production, potential, local demand etc. in each area;
- iii identify technical and business problems related to horticultural/ HVA development in these areas and propose solutions accordingly;
- iv assess the role of moisture retention materials in promotion of horticultural plants in deserts;
- v design a comprehensive strategy for crop diversification from traditional crops to high value plantations including orchards, vegetables and flowers;
- vi develop technology driven programs to improve productivity and quality by introduction of improved varieties, medicinal plants, rejuvenation with improved cultivars, high density plantations, use of high efficiency irrigation systems etc. for each area; and
- vii develop guidelines for successful adoption of horticulture by the farmers in each area.

12. Assistant Agriculture Engineer (National: 09 person-months indicative): Responsibilities of the Assistant Agriculture Engineer will include but not limited to the following:

- i. work under the WMS/ AE and assist him for carrying out the planned activities;
- ii. design CAD plans in consultation with all stakeholders for different areas;
- iii. modify the CAD plans/ designs of proposed project interventions for cost effectiveness and technical suitability;
- iv. coordinate with other team members for preparation of various CAD plans for various activities; and
- v. perform other duties as assigned by the project management.

13. High Efficiency Irrigation Systems Specialist (National: 02 person-months indicative): The High Efficiency Irrigation Systems Specialist will report to the Team Leader and work with the Irrigation Agronomist for planning, design, installation and management studies and formulation of the operation procedures for the system. He will support the Team Leader in preparation of related reports and returns.

14. Range Management Specialist (National: 02 person-months indicative): Responsibilities of the Range Management Specialist will include but not limited to the following:

- i. under the Team Leader, the Range Management Specialist will work closely with Irrigation Planning Engineer and Livestock Management Specialist to develop

an integrated sustainable development plan for D G Khan hill torrents areas of which livestock would be the key component.

- ii. quantify the range area to be allocated for each water storage area and plants and shrubs to be planted under range management for the size and composition of the herd assigned to each water storage area
- iii. advise if one water storage area would require to facilitate better management by reducing crowding on one water storage area; and
- iv. advise on possibility of value chain in provision of feed and other inputs.

15. Livestock Development Specialist (National: 03 person-months indicative): Responsibilities of the Livestock Development Specialist will include but not limited to the following:

- i. under the Team Leader, the Livestock Development Specialist will work closely with Irrigation Planning Engineer and Livestock Management Specialist to develop an integrated sustainable development plan for D G Khan hill torrents areas of which livestock would be the key component.
- ii. determine the additional veterinary services required for the proposed intervention including the number of field centers, the facilities (infrastructure, medicines, and equipment) needed, with their investment and annual running costs;
- iii. quantify the range area to be allocated for each water storage area and plants and shrubs to be planted under the range management for the size and composition of the herd assigned to each water area;
- iv. advise on possibility of value chain in provision of feed and other inputs and handling and marketing of products like wool and animals; and
- v. explore the possibility of attracting meat companies to invest in the project area and enter into contract with the locals that would create local employment and benefit both the farmers and the companies.

16. Climate Change Specialist (National: 02 person-months indicative): The Climate Change Specialist will assist and support the relevant principal international specialists and while working under the supervision of the Team Leader will receive technical guidance directly from the relevant international specialist. In each case, he will assist in carrying out all aspects of the relevant international specialists' TOR and in his / her absence accept full responsibility for all aspects of his / her TOR. Therefore, detailed individual terms of reference are not separately prepared for this sort of individual.

17. GIS Expert (National: 04 person-months indicative): Responsibilities of the GIS Specialist will include but not limited to the following:

- i. digitize all project area using satellite imageries starting from head up to tail level;
- ii. establish GIS database for the irrigation and drainage network providing reach-wise detail of hydraulic and command parameters based on both previous data

and new design parameters to expand its utility and create a central data depository of the PID;

- iii. develop / refine GIS database for groundwater monitoring system in the canal commands using coordinates of the observation points collected by Directorate of Land Reclamation (DLR) of PID. Where ever errors will be found in the coordinates, the consultants will get it corrected through DLR field staff and update the same in GIS database. All past available data relevant to the observation points e.g. depth to water table will be made part of the database;
- iv. develop groundwater quality, depth and elevation maps for the project area;
- v. digitize / extract major rail/road network present within the canal project area; and
- vi. develop / process maps in the printable form and print maps at appropriate scale in the format and quantity as per requirement of the client; and

18. Junior Sociologist (National: 12 person-months indicative): Responsibilities of the Junior Sociologist will include but not limited to the following:

- i. assist PMO in the development and establishment of an appropriate M&E strategy and plans for rehabilitation and upgrading of the facilities in the priority projects;
- ii. M&E systems referred to above will include input, progress, output and impact indicators and be computerized so they are compatible with and form a part of the MIS for the project to which they apply;
- iii. plan, design and supervise the conducting of baseline, intermediate and end of Project socio-economic surveys in selected parts in the project area;
- iv. develop appropriate analytical methodology for socio-economic impact assessment; and
- v. conduct in depth workshops for PMO/PID staff and for those who will carry out the surveys in the field covering the survey design, sampling criteria, questionnaire requirements, interview methodology and survey analysis.

19. Junior Resettlement Expert (National: 9 person-months indicative): Responsibilities of the Junior Resettlement Expert will include but not limited to the following:

- i. assess all potential; resettlement impacts from the range of interventions proposed for the priority projects within the umbrella of ADB's resettlement policy;
- ii. prepare a resettlement framework consistent with ADB guidelines for each priority project;
- iii. prepare resettlement plans required in collaboration with Resettlement Unit established in the PMO and relevant PID staff; and

- iv. develop detailed implementation arrangements to carry out resettlement activities under all projects and assess the capacity within PMO/PID and other relevant agencies with respect to resettlement and prepare detailed capacity development programs for resettlement activities to be carried out under the projects.

20. Social Development and Gender Expert (preferably female) (National: 03 person-months indicative): Responsibilities of the Social Development and Gender Expert will include but not limited to the following:

- i. develop the Gender Action Plan through close working with the project team;
- ii. develop community mobilization and training plan aligned with the GAP targets and lead community consultations for the identification of trainees for livelihood raising programs as detailed in GAP;
- iii. prepare data collection tools for collecting baseline information required for upgradation of schools, health facilities and vocational trainings etc in selected project areas;
- iv. conduct qualitative studies at suitable sites of how women see the impact on their lives of provision of improved health care, skills training, education, and recreational provision; and
- v. conduct field visits and any other function and responsibility, as assigned by the Employer.

21. Survey Engineer (National: 06 person-months indicative): Responsibilities of the Survey Engineer will include but not limited to the following:

- i. maintain close coordination with the GIS Expert for sharing satellite imagery;
- ii. procure from Survey of Pakistan updated survey maps covering the project area; and
- iii. establish and maintain bench marks at suitable locations around the project facilities.

22. Junior Engineer (Civil / Mechanical / Electrical) (National: 75 person-months indicative): Responsibilities of the Junior Engineer will include but not limited to the following:

- i. Assist the Team Leader / Deputy Team Leader and other experts in carrying out their TORs; and
- ii. Assist the Team Leader / Deputy Team Leader and other experts in designing, prepare relevant records, work measurements, collecting and keeping the records for use by the professional staff, preparation of progress reports, financial statements, etc.

23. Project Coordinator (National: 36 person-months indicative): Responsibilities of the Project Coordinator will include but not limited to the following:

- i. assist the Project Director, PMO, Punjab Barrages in maintaining an effective coordination with the Consultants' team, Review Panel and other stakeholders for efficient performance of the consulting services;
- ii. assist the PMO, Punjab Barrages in processing of assignment-related cases, arranging meetings and maintaining close follow-up action with the Consultants, Review Panel, government functionaries and other stakeholders;

24. Senior Engineer Procurement (National: 18 person-months indicative): Responsibilities of the Senior Engineer Procurement will include but not limited to the following:

- i. provide capacity support to the PMO in all procurement activities regarding goods, works and services;
- ii. assist the PMO in preparing/ up-dating procurement plans;
- iii. oversee the working of Consultants and Contractors engaged by PMO in contract management/ administration;
- iv. carry out procurement risk assessment and general procurement capacity development;
- v. building PID's capacity to become accredited for Alternate Procurement Agency;
- vi. assist the PMO in reviewing and determining contractor's claims; and
- vii. assist and render advice to the PMO in any contractual issue that may arise.

25. Safeguard Specialist (National: 18 person-months indicative): Responsibilities of the Safeguard Specialist will include but not limited to the following:

- i. review Resettlement Plan (RP) and resettlement conditions of loan and ensure these are followed during the award of contract and construction work;
- ii. review RP for consistency with SPS 2009 and outline of a RP. Identify any gaps and assist PMO in addressing those gaps to ADB's satisfaction; and
- iii. assist and render advice to PMO in any other Resettlement issue that may arise during design stage.

26. Agronomist (National: 18 person-months indicative): Responsibilities of the Agronomist will include but not limited to the following:

- i. review the available resources of each area in terms of agronomic aspects including irrigation methods, efficacy of existing agricultural practices, irrigation requirements, water productivity, cropping patterns & intensities, input use levels, crop yields etc.;
- ii. address issues and suggest solutions to the problems related to crop production as confronted by the farmers for bringing the wastelands under cultivation;

- iii. Identify and recommend water efficient crop varieties based on soil and climatic conditions for each area/ zone;
- iv. review crop water requirements (CWR) by using climatic data (rainfall, sunshine, humidity, wind speed, temperature etc.);
- v. review guidelines/ manual for irrigation and fertigation schedules to meet input requirements of proposed crops in each area;
- vi. review crop budgets/ farm budgets under existing and proposed conditions for identifying economically viable interventions and cropping patterns for each area; and
- vii. review and identify requisite agronomic support to be provided to the farmers for successful adoption of proposed interventions to enhance crop & water productivities for each area.

5. REPORTING REQUIREMENTS AND TIME SCHEDULE FOR DELIVERABLES

Reporting Requirements:

13. The consultants will have a dual reporting function to the Executing Agency (EA) and ADB. The consultants will prepare the following reports in English with Arial font (12 for headings and 11 for body text). The tables should use 10 Arial. The consultant will submit Table of Contents (TOC) for each report for prior approval of the client. A brief description of some important reports is given below.

Quarterly Progress Report: Ten copies of Quarterly Progress Reports shall be presented quarterly before the 10th day of the subsequent quarter and shall indicate progress of the implementation of the consultancy contract. The issues that may hinder implementation as planned shall be flagged in these reports along with the suggested solutions.

Resettlement Plans: The project falls in “Category A” under ADB’s resettlement guidelines meaning that there may likely be significant impacts for at least 200 persons due to the project. Based on this reclassification, the TA Consultants have developed a draft resettlement framework, and resettlement action plan (RAP) for a subproject that was likely to encounter the greatest resettlement impacts.

The ADB and Government of Punjab have agreed to the following principles with regard to resettlement under the project

- (i) the approach to resettlement under the project should not be to remove all persons who have encroached on the right of way(s), but to move only those persons who will be directly affected,
- (ii) design will be drafted with the objective of minimizing resettlement activities, and
- (iii) contract packages and execution of civil works will be directed in such a way to minimize resettlement activities.

The Consultants would assist PMO in updating the RAP prepared during PPTA on the basis of the detailed design and assist PMO in preparing RAP to meet funding agency's requirements for any other area affecting more than 200 persons.

Draft and Final Design Criteria: The Consultants shall prepare the draft design criteria for review by the Client. The final design criteria shall be prepared after incorporating / remedying the comments made by the Client.

Detailed Engineering Design Report: Both the draft and final version of Detailed Design Report shall be prepared separately. The Report shall comprise of sections / sub-sections covering detailed field surveys, investigations and all types of engineering and economic studies. The Report shall consist of detailed design after incorporating comments of the Client. The reference of the formulae used in calculations will be mentioned in the calculation sheets in the remarks column for ease of review. Soft copy of the design calculations in Excel with formula format or any other software used will be submitted with the design reports.

Tender drawings and Construction Drawings: Based on the detailed design carried out, the consultants shall prepare tender drawings as well as construction drawings for all facets of the construction works.

Engineer's Estimate: Prepare the Engineer's Estimate of the expected cost of construction immediately prior to the finalization of bidding documents. This estimate shall be based on the most up-to-date assessment of construction rates prevailing at the time and shall include all items such as contractor's mobilization and insurance costs, allowance for all necessary provisional sums and estimated day works, and contingencies.

Deliverable:

14. The consulting services will be for 36 months and tentatively from April 2020 to March 2023. The schedule for various reports and documents that are likely to be generated has been prepared. Additional reports shall be developed as required. The consultants will supply the deliverables as per schedule given below along with the respective soft copy thereof:

Report	No. of Copies	Submission deadline
Draft Inception Report	10	One (01) month after the Commencement of Services
Final Inception Report	25	Two (02) months after the Commencement of Services
Quarterly Progress Report	10	10 th of the following Quarter
Identified Priority Project – A Remodeling and Upgrading of Dera Ghazi Khan Canal System		
Draft Updated Feasibility Report	25	04 months after the Commencement of Services
Final Updated Feasibility Report	25	05 months after the Commencement of Services

Draft Design Criteria	10	07 months after the Commencement of Services
Final Design Criteria	10	08 months after the Commencement of Services
Draft Design Reports including detailed Calculation folder and software	10	11 months after the Commencement of Services
Final Design Reports	25	12 months after the Commencement of Services
Resettlement Plans	10	07 months after the Commencement of Services
ESIA, EMP, EMMP, GAP, Social framework agreement	10	08 months after the Commencement of Services
Draft PC-I	25	12 months after the Commencement of Services
Final PC-I	25	13 months after the Commencement of Services
Engineer's Estimate	10	13 months after the Commencement of Services
Complete set of Bidding Documents including Technical Specifications and Tender Drawings	25	14 months after the Commencement of Services
Complete set of Construction Drawings for all Civil, Mech. and Electrical works	25	15 months after the Commencement of Services
Development / Review of System's Operational Rules	10	16 months after the Commencement of Services
Identified Priority Project – B Rehabilitation and Upgrading of Upper Jhelum Canal System		
Draft Updated Feasibility Report	25	13 months after the Commencement of Services
Final Updated Feasibility Report	25	14 months after the Commencement of Services
Draft Design Criteria	10	16 months after the Commencement of Services
Final Design Criteria	10	17 months after the Commencement of Services
Draft Design Reports including detailed Calculation folder and software	10	21 months after the Commencement of Services
Final Design Reports	25	22 months after the Commencement of Services
Resettlement Plans	10	20 months after the Commencement of Services
ESIA, EMP, EMMP, GAP, Social framework agreement	10	21 months after the Commencement of Services
Draft PC-I	25	22 months after the Commencement of Services
Final PC-I	25	23 months after the Commencement of Services
Engineer's Estimate	10	23 months after the Commencement of Services
Complete set of Bidding Documents including Technical Specifications and Tender Drawings	25	24 months after the Commencement of Services
Complete set of Construction Drawings for all Civil, Mech. and Electrical works	25	25 months after the Commencement of Services

Development / Review of System's Operational Rules	10	26 months after the Commencement of Services
Identified Priority Project – C Greater Thal Canal (Phase-III) Project		
(a) Greater Thal Canal (Phase III-A) – Dhingana Branch System and Mehmood Sub Branch Systems		
Draft Updated Design Criteria (for both GTC Phase III-A and III-B)	10	27 months after the Commencement of Services
Final Updated Design Criteria (for both GTC Phase III-A and III-B)	10	28 months after the Commencement of Services
Draft Updated Design Reports including detailed Calculation folder and software	10	30 months after the Commencement of Services
Final Updated Design Reports	25	31 months after the Commencement of Services
Resettlement Plans	10	29 months after the Commencement of Services
ESIA, EMP, EMMP, GAP, Social framework agreement	10	30 months after the Commencement of Services
Draft PC-I	25	32 months after the Commencement of Services
Final PC-I	25	33 months after the Commencement of Services
Engineer's Estimate	10	33 months after the Commencement of Services
Complete set of Bidding Documents including Technical Specifications and Tender Drawings	25	34 months after the Commencement of Services
Complete set of Construction Drawings for all Civil, Mechanical and Electrical works	25	35 months after the Commencement of Services
Development / Review of System's Operational Rules	10	36 months after the Commencement of Services
(b) Greater Thal Canal (Phase III-B) – Noorpur Branch System		
Draft Design Reports including detailed Calculation folder and software	10	30 months after the Commencement of Services
Final Design Reports	25	31 months after the Commencement of Services
Resettlement Plans	10	32 months after the Commencement of Services
ESIA, EMP, EMMP, GAP, Social framework agreement	10	32 months after the Commencement of Services
Draft PC-I	25	32 months after the Commencement of Services
Final PC-I	25	33 months after the Commencement of Services
Engineer's Estimate	10	34 months after the Commencement of Services
Complete set of Bidding Documents including Technical Specifications and Tender Drawings	25	35 months after the Commencement of Services
Complete set of Construction Drawings for all Civil, Mech. and Electrical works	25	36 months after the Commencement of Services

Development / Review of System's Operational Rules	10	36 months after the Commencement of Services
Identified Priority Project – D Remodeling of R-Q, Q-B & B-S Link Canals		
(a) Remodeling of Rasul-Qadirabad (R-Q) Link Canal		
Draft Updated Feasibility Report	25	15 months after the Commencement of Services
Final Updated Feasibility Report	25	16 months after the Commencement of Services
Draft Design Criteria	10	17 months after the Commencement of Services
Final Design Criteria	10	18 months after the Commencement of Services
Draft Design Reports including detailed Calculation folder and software	10	20 months after the Commencement of Services
Final Design Reports	25	22 months after the Commencement of Services
Resettlement Plans	10	18 months after the Commencement of Services
ESIA, EMP, EMMP, GAP, Social framework agreement	10	19 months after the Commencement of Services
Draft PC-I	25	23 months after the Commencement of Services
Final PC-I	25	24 months after the Commencement of Services
Engineer's Estimate	10	25 months after the Commencement of Services
Complete set of Bidding Documents including Technical Specifications and Tender Drawings	25	26 months after the Commencement of Services
Complete set of Construction Drawings for all Civil, Mech. and Electrical works	25	27 months after the Commencement of Services
Development / Review of System's Operational Rules	10	27 months after the Commencement of Services
(b) Remodeling of Qadirabad-Balloki (Q-B) Link Canal		
Draft Updated Feasibility Report	25	22 months after the Commencement of Services
Final Updated Feasibility Report	25	23 months after the Commencement of Services
Draft Design Criteria	10	25 months after the Commencement of Services
Final Design Criteria	10	26 months after the Commencement of Services
Draft Design Reports including detailed Calculation folder and software	10	27 months after the Commencement of Services
Final Design Reports	25	28 months after the Commencement of Services
Resettlement Plans	10	26 months after the Commencement of Services
ESIA, EMP, EMMP, GAP, Social framework agreement	10	27 months after the Commencement of Services
Draft PC-I	25	29 months after the Commencement of Services
Final PC-I	25	30 months after the Commencement of Services

Engineer's Estimate	10	31 months after the Commencement of Services
Complete set of Bidding Documents including Technical Specifications and Tender Drawings	25	32 months after the Commencement of Services
Complete set of Construction Drawings for all Civil, Mech. and Electrical works	25	33 months after the Commencement of Services
Development / Review of System's Operational Rules	10	33 months after the Commencement of Services
(c) Remodeling of Balloki-Suleimanki (B-S) Link Canal		
Draft Updated Feasibility Report	25	28 months after the Commencement of Services
Final Updated Feasibility Report	25	29 months after the Commencement of Services
Draft Design Criteria	10	30 months after the Commencement of Services
Final Design Criteria	10	31 months after the Commencement of Services
Draft Design Reports including detailed Calculation folder and software	10	32 months after the Commencement of Services
Final Design Reports	25	33 months after the Commencement of Services
Resettlement Plans	10	32 months after the Commencement of Services
ESIA, EMP, EMMP, GAP, Social framework agreement	10	32 months after the Commencement of Services
Draft PC-I	25	34 months after the Commencement of Services
Final PC-I	25	35 months after the Commencement of Services
Engineer's Estimate	10	35 months after the Commencement of Services
Complete set of Bidding Documents including Technical Specifications and Tender Drawings	25	36 months after the Commencement of Services
Complete set of Construction Drawings for all Civil, Mech. and Electrical works	25	36 months after the Commencement of Services
Development / Review of System's Operational Rules	10	36 months after the Commencement of Services
Project Completion Report	25	36 months after the Commencement of Services

[illegible]

6. CLIENT'S INPUT AND COUNTERPART PERSONNEL

15. The Client shall make available to the Consultants at no charge the following facilities:

- i. Access to all reports, studies, data, photographs, maps, and institutions relating to the works, access to all sites for surveys and investigations.
- ii. Assistance to procure all necessary administrative documents including but not limited to visas, exchange control documentation, import licences, exemption certificates, work permits, driving licences, resident visas.
- iii. Free use of vehicles⁸ procured by the Consultants for official purposes and approved personal use, during the entire period of consultancy services. The vehicles procured by the Consultants will be returned to Client after the completion of the Consultancy services.
- iv. Permission to use facilities such as Guest Houses, payable at the official rates, will be granted where possible, to members of the Consultants' staff in connection with their official duties.

7. INFORMATION TO FACILITATE PROPOSAL PREPARATION

The information on engineering design of the project is open/ available to all shortlisted firms for fair competition and can be obtained from the Project Management Office at the address indicated in Clause 2.1 of Data Sheet, RFP.

⁸ As per Client indicative estimate, consultant may provide four (04) vehicles (one car 1300 cc, two cars 1000 cc, one double cabin pickups (4x4) and one motorcycle (70 cc) for their use in performance of the assignment. However, actual requirements and pricing of the same shall be done by the consultants themselves in their proposals as per their own experience and assessment of the work quantum.

Annexure - A

Annexure -A**SUMMARY OF PRIORITY PROJECTS****PROJECT A: Remodeling and Upgrading of Dera Ghazi Khan Canal System**

Feasibility Study Consultants: Joint Venture of Engineering & Agricultural Service Entity-Pakistan and Quality Engineering and Consultancy Services

Culturable Command Area: 384,082 ha (949,087 acre)

Location: Dera Ghazi Khan and Rajanpur tehsils

Estimated Cost: \$68.00 million

Status of Studies and Specific Issues: Dera Ghazi Khan Canal, a non-perennial channel, off taking from Taunsa Barrage on the right bank of river Indus was commissioned in 1959. DG Khan main canal was initially designed to carry 8,757 cusecs and later on remodeled to 11,549 cusecs as its authorized discharge. All structures on the main canal have been designed for the same discharge. It was anticipated at the time of designing of DG Khan Canal that area between DG Khan Canal and River Indus besides some partial area on the right side of DG Khan Canal would be irrigated through DG Khan Canal system, for which DG Khan Canal will be remodeled to carry a discharge of 14,503 cusec. Though the capacity of DG Khan was enhanced from 8,757 cusecs to 11,549 cusecs, it is still unable to carry the anticipated discharge of 11,549 cusecs due to problems in approach angle of river resulting in un-balanced flow, deterioration of banks, excessive berm growths and due to abnormal silt deposit in the bed of channel which ranges from 1 ft to 2.5 ft in depth resulting incapacitation of the channel section.

The Feasibility Study for Remodeling and Upgrading of Dera Ghazi Khan Canal System was awarded to **Joint Venture of Engineering & Agricultural Service Entity-Pakistan and Quality Engineering** and Consultancy Services by Executive Engineer, DG Khan Canal Division. The main objectives of the feasibility study were as follows:

- i) Due to construction of Kachi Canal on right side of D.G.Khan canal, flow pattern of hill torrent flood water across hill torrent crossing structure already constructed on D.G.Khan canal system has been changed.
- ii) To carry out hydraulic survey of D.G.Khan Canal system, establish bottlenecks / problems in feeding D.G.Khan Canal to its designed discharge and propose solution for improvement of efficiency of D.G.Khan Canal system.
- iii) There is chronic tail shortage problem especially in Rajanpur Canal Division which requires detailed investigation and engineering solution to the problem.

The feasibility study for DG Khan Canal was completed in January 2018 which indicated that the viability of the Project with high rate of return which is obvious on the count that if the system can deliver 11,549 cusecs against the presently running capacity of 8,757 cusecs only, the difference is almost 1/3rd of the capacity and the rehabilitation would result in increase in intensity and yields both. The feasibility has been prepared for discharge of 11,549 cusecs however the structures have been checked for 14,503 cusecs, the ultimate discharge.

PROJECT B: Rehabilitation and Upgrading of Upper Jhelum Canal (UJC) System

Feasibility Study Consultants: Barqaab Consulting Services (Pvt.) Ltd. (Lead), Rehman Habib Consultants (Pvt.) Ltd. (JVP) and Engineering & Agricultural Service Entity-Pakistan (JVP)

Culturable Command Area: 244,328 ha (603,749 acre)

Location: Between Mangla Dam and Khanki Barrage. The canal **traverses through the districts of Jhelum, Gujrat, Mandi Bahauddin, and Gujranwala**

Estimated Cost: \$174.00 million

Status of Studies and Specific Issues: The Upper Jhelum Canal Project area lies to Longitude – 73° 42' 55" to 74° 01' 23" of East and Latitude – 32° 27' 44" to 33° 05' 36" of North and is located between Rim stations of Mangla on Jhelum River and New Khanki Barrage on Chenab River. The Upper Jhelum Canal traverses in districts of Jhelum, Gujrat, Mandi Bahauddin and Gujranwala.

UJC was designed in 1905 and commissioned in 1915. The design discharge of UJC at the time of commissioning was 8,500 cs. However, in 1923 the design discharge of the canal was increased to 9,031 cs. The canal was partly remodeled in 1982 on the request of WAPDA for providing 1,800 cs of additional water to Rasul Hydropower Station but head discharge was restricted to 8,500 cs due to abnormal scour in the head reach. Since then it is running with restricted head discharge.

UJC is designed to serve as a Link channel connecting River Jhelum with River Chenab to mitigate the shortages of canal supply upstream of New Khanki Barrage. The off-taking system of New Khanki Barrage as Lower Chenab Canal (LCC) needs about 6,000 - 8000 cs during certain lean periods (Rabi season) from UJC Link channel.

At present, the UJC is unable to deliver its authorized discharge of 8,500 cs and facing severe silting problems in the middle and tail reaches particularly reach RD 244+000 to 417+805 (Tail) is badly silted up. The recommended freeboard (FB) of 3 ft is not available in major portion of the canal sections and almost upstream of all hydraulic structures (bridges, falls, X-regulators and head regulator of the distributaries). There are chances of breaches due to weak banks and overflowing sections, especially in reach downstream of Khokhra Head Regulator. Most of the worn-out decking of bridges and regulators need replacement. The overall conveyance efficiency has significantly decreased and most of the Gates and Gearing systems have badly deteriorated.

The Feasibility Study for Remodeling of Upper Jhelum Canal was awarded to **Joint Venture of Barqaab Consulting Services (Pvt.) Ltd. (Lead), Rehman Habib Consultants (Pvt.) Ltd. (JVP) and Engineering & Agricultural Service Entity-Pakistan (JVP)** in February, 2016 by Executive Engineer, Jhelum Division. The main objectives of this study were as follows:

- i) To improve conveyance efficiency, reliability and durability of the system as per enhanced proposed discharged by rehabilitating / remodeling Upper Jhelum Canal.
- ii) To ensure water supply for Rasul Power House.
- iii) To ensure water supply at tail for Shadiwal Power House.
- iv) To ensure irrigation supplies for Khanki heads in dry / rabi season.

The feasibility study (FS) report was submitted in May 2017 and it has been discussed at various forums. The canal and structures remodeling will (i) increase the canal capacity at head from 8,500 cubic feet per second (cfs) to 12,655 cfs; and (ii) enable two (02) power houses to achieve full potential of 33 megawatt (MW) up from current generation of 10 MW. The Consultants

recommended the project being technically and economically viable on fast track basis to offset the shortage of River Chenab at New Khanki Barrage during the winter season.

Several alternatives were investigated at the feasibility stage. However, the report has not been rigorously reviewed by experts and hence there is little agreement among various Punjab Irrigation Department (PID) specialists on the final solution.

PROJECT C: Greater Thal Canal (GTC) Project (Phase III) - (Dhingana Branch, Nurpur Brach And Mahmood Sub Branch Systems)

Detailed Design Consultants: JV of National Engineering Services Pakistan, National Development Consultants (Pvt.) Ltd., Associated Consulting Engineers-ACE (Pvt.) Limited and Barqaab Consulting Services (Pvt.) Ltd. in association with Engineering General Consultants EGC (Pvt) Limited.

Culturable Command Area: 440,850 ha (1,088,900 acre)

Estimated Cost: \$600 million

Project Background: Greater Thal Canal Project, with a designed capacity of 8,500 cusec (240 m³/s), aims at new irrigated agriculture development of 1.738 million acres (703,345 ha) CCA of land, in the eastern part of Thal Doab falling within the boundaries of Bhakkar, Layyah, Khushab, Jhang and Muzaffargarh districts. The project envisages increasing crop production from 12,032 ton/ annum to 2,250,950 ton/ annum at full development ensuring food security for the increasing population of Pakistan. The project will not only result in boosting of economy but will also bring improvement in quality of life associated with socio-economic and socio-cultural changes in the life of poor people of the project area.

The overall project comprises main canal (34 km length – lined) with 5 branch canals (Mankera, Chaubara, Dhingana, Nurpur and Mahmood Sub Branch) in a length of 341 km , distributaries/ minors of about 2,000 km length. The Project PC-I amounting to Rs. 30,467 million was approved by ECNEC in 2002. The design capacity Greater Thal canal is 8,500 cusec with water allowance of 3.88 cusec/ 1000 acres. The Project feasibility study was prepared by the Consultants hired by WAPDA during 1992-94 and detailed design for the entire scheme was completed in 2007.

Project Phasing: Greater Thal Canal (Phase-I) works, covering the construction of canals up to minors for a CCA of 0.356 million acres (144,068 ha), were completed under WAPDA during 2008 at a cost of Rs. 10.17 billion. The GTC overall project was then handed over to Punjab Irrigation Department in October, 2009 for operation and implementation of remaining two phases. The Phase II project (Choubara) was decided to be constructed by the provincial government, and the WAPDA detailed design was updated by the consultant engaged by the PID in 2017-2018. The PID and ADB agreed in April 2019 that the Choubara branch system construction will be shifted from the provincial government financing to ADB financing. **As regards the last Greater Thal Canal (Phase-III) Project,** the Asian Development Bank (ADB) has agreed to include it in the ensuing ADB's Project Readiness Financing Facility (PRF) for developing an implementation project. The current consulting assignment envisages, amongst others, updating the project detailed design and preparation of land acquisition and resettlement plan, social safeguard documents, project PC-I and procurement documents including technical specifications etc.

Phase-I: Construction Completed by WAPDA in 2008

- Construction of main canal and 8 No. direct distributaries with minors.
- Construction of Mankera branch and distribution system.

Phase-II: Undertaken under ADB Financing

- Updated detailed design and construction of Chaubara branch and distribution system will be done under ADB Financing.

Phase-III: Planned to be taken up by PID under PRF

- Updating detailed design and construction of Dhingana branch and distribution system.
- Updating detailed design and construction of Nurpur branch and distribution system
- Updating detailed design and construction of Mahmood Sub branch and distribution system.

Salient features of Greater Thal Canal (Phase-III)

Sr. No.	Canal	Discharge (Cusecs)	CCA (Acres)	Canal Length
1	Dhingana Branch Canal	3,879	200,931	Branch Canal: 91 km Distributaries: 450 km Minors: 101 km Outlets: 1,014 No.
2	Nurpur Branch Canal	1,500	124,615	Branch Canal: 58 km Distributaries: 224 km Minors: 128 km Outlets: 609 No.
3	Mehmood Sub Branch	1,480	115,304	Sub Branch Canal: 54 km Distributaries: 296 km Minors: 17 km Outlets: 527 No.

PROJECT D: Remodeling of R-Q, Q-B & B-S Link Canals

Feasibility Study Consultants: Joint Venture of National Engineering Services Pakistan (Pvt.) Limited (NESPAK), AAB (Pvt.) Limited (AAB), and Development and Management Consultants (DMC).

Proposed Culturable Command Area: 1,083,159 ha (2,676,544 acres)

Estimated Cost: \$50.00 million

Project Background: Rasul-Qadirabad (R-Q), Qadirabad-Balloki (Q-B), and Balloki-Suleimanki (B-S) Link Canal System is the water transfer system where the capacity enhancement is needed to remove capacity constraint for reducing water shortages in the canal commands served from this system and rehabilitating the structures where necessary.

The **R-Q Link Canal is the first tier of three link** canals forming Rasul-Qadirabad-Balloki-Suleimanki Link System which connects four eastern rivers i.e. Jhelum, Chenab, Ravi and Sutlej. R-Q link offtakes from Rasul Barrage with a full supply discharge of 19,000 cusec. This unlined canal is 29 miles long, and outfalls into River Chenab upstream of Qadirabad Barrage. This Link Canal meets the water transfer requirement of Q-B Link, which in turn fulfills water requirement of canal systems offtaking from Balloki Barrage on River Ravi and Suleimanki and Islam Barrages on River Sutlej.

The link canal operation data shows that the link remains closed for over a month, mostly during the month of January. From May to July when the crop water demand is high, the link runs to its

full capacity. Other high demand periods may occur in early Rabi at the time of sowing during which the canal is to operate at higher discharges. From June 11 to August 01, the flows in R-Q Link significantly reduce up to 5,000 cusec. After August-1 flow rises in Link and reaches near to its full capacity in October-1.

On the basis of calculated water surface profile with computer model HEC-RAS; following are the design parameters of R-Q Link Canal for discharge of 24,000 cusec.

	Proposed Design for 24,000 cusec		
	Original Design (19,000 cusec)	Reach-I (0+000 to 65+656)	Reach-II (65+656 to 145+246 Tail)
Discharge Q19,000 cusec	24,000 cusec	24,000 cusec	
Average bed width	330 ft	380 ft	380 ft
Full Supply Depth	14.0 ft	18.93 ft	17.09 ft
Water surface slope	1 in 10,500	1 in 18650	1 in 13340
Side slope	3:1 & 2:1	0.5:1	0.5:1
Velocity	3.70 ft/sec	3.25 ft/sec	3.61 ft/sec
Manning's Coefficient	0.021	0.0225	0.0225
Bed level at RD 0+000	703.08 ft	696.89 ft	
Water level of RD 0+000	717.08 ft	715.82 ft	

All hydraulic structures on the link canal have been checked for safety for existing discharge (19,000 cusec) and for proposed design discharge for 24,000 cusec. It is observed that these structures are incapable of dissipating the energy, resulting in deep scour pits and embayment downstream. Main structures on R-Q Link Canal are Remodeling of Control Structures (RD 0+000 & RD 65+656), Phalia Disty Aqueduct Retaining Wall, Escape Structure and Escape Channel at RD 139+300, Rehabilitation of Budhi Nullah Drainage Syphon at RD 95+855.

Q-B Link Canal is the second tier in the inter-river water transfer system. With a design discharge of 25,000 cusec, this Link Canal takes off from Qadirabad Barrage and outfalls into Ravi River upstream of Balloki Barrage. Although the capacity of this canal has been increased from 18,500 cusec to 25,000 cusec, the structures have not been correspondingly modified. Therefore backing up of water takes places at various regulation structures even at discharge of 22,000 cusec particularly at the aqueduct of Gajar Gola distributary and LCC Complex. The maximum discharge which is presently carried by the canal is only 22,000 cusec against the official figure of 25,000 cusec. A detailed assessment of need for capacity enhancement of Link canal system including Q-B Link Canal has been carried out. The analysis shows that rehabilitation and upgrading of Q-B Link is required to restore the capacity of Link and its structures upto 25,000, cusec to enable it to run in accordance with the approved L-section. This will also empower this link canal to carry the enhanced discharge of 24,000 cusec brought by R-Q Link, after its upgrading. Since Balloki Barrage receives its flow from two other sources i.e. MR Link and Upper Chenab Canal also, the restoration of the capacity of Q-B, Link up to 25,000 cusec shall be sufficient to meet the requirement of the system.

Although the Q-B Link was remodeled for enhanced discharge of 25,000 cusec in 1989 but only minor repair works for structures were carried out. It has been found from present study that design discharge (25,000 cusec) could be adequately accommodated in the existing channel prism with increased depth and bed width due to scoured bed of the canal and from re-sectioning done probably during remodeling of 1989. With erosion of both side berms, channel bed width has increased from 335 ft to 388 ft in RD 0+000 to RD 79+874; and from 300 ft to 355 ft in RD 79+874 to tail.

There are six hydraulic structures i.e. head regulator, LCC Complex at RD 81+274, control structures at RD 182+102, 271+655, 304+985 and tail structure at RD 379+265. General conditions of these structures are satisfactory. However, hydraulic jumps were not fully contained within the stilling basin. The condition of impact/ deflector/friction blocks is good. Deep pits were however observed downstream of these structures; depth of these pits varies from 15-45 ft.

The Balloki-Suleimanki Link Canal is the third and last segment of this inter-river transfer system. This Link canal offtakes from River Ravi at Balloki Barrage and flows in a southern direction for distance of 53 miles towards River Sutlej where it outfalls at a point approximately 10 miles above Suleimanki Barrage. In June 1960, capacity of the Link was increased from 15,200 cusec to 18,500 cusec. For carrying this enhanced discharge, the first 14 miles unlined reach of the canal was widened to accommodate additional 6,500 cusec, and thereafter a new (unlined) canal, was dug to run parallel to existing lined BS-I to carry additional discharge of 6,500 cusec. This parallel unlined canal is designated as Balloki-Suleimanki-II (BS-II) Link Canal.

To meet the increased irrigation demand of Sutlej Valley Canals, BS Link Canal System was remodeled repeatedly by Irrigation Department, first from 18,600 cusec to 22,000 cusec, and then from 22,000 cusec to 24,500 cusec. In the most recent remodeling of canal in 2003-2005, the capacity of BS-II was raised from 6,500 cusec to 9,000 cusec. The BS-II Link runs parallel to the BS-I along its left, or up-doab side, for a distance of 38 miles and ends at tail regulator constructed adjacent to the outfall structure of the BS-I. The two Links discharge into a common outfall channel that extends about a mile into Sutlej River.

Main design parameters of BS Link Canal for raised discharge (24,500 cusec) are:

Property	Unit	BS Link	BS-I Link	BS-II Link	
		RD 0+000 to RD 73+250	RD 73+250 to RD 266+000	RD 0+000 to RD 33+430	RD 33+430 to RD 193+339
Discharge	Cusec	24,500	15,000	9,000	9,000
Bed width	ft.	405.0	112.0	230.0	230.0
Water depth	ft.	15.20	18.0	10.0	10.60
Slope	ft./ft.	1:10,000	1:8,000	1:8,000	1:8,000
Lacey 'f'	-	0.98	0.97	1.02	0.98
Manning coefficient	-	0.0224	0.017	-	-

It is now proposed to enhance the capacity of BS Link by another 4,000 cusec to supply water for irrigated agriculture development in Smaller Cholistan. It may be observed that for enhanced discharge condition the water levels are higher for about 0.30 ft from last design condition. Increased depth for enhanced discharge is accommodated in the scour bed. Existing bed levels are lower than last design bed levels throughout the length and increase in downstream reach. A marginal increase of 0.3 ft in full supply level shall not affect the hydraulics at the head regulator of the B-S Link.

The observed cross-sections show, that freeboard is less than 3.0 ft in the reach from RD 0+000 to RD 13+000. Therefore, embankment has been raised in this reach to provide the required freeboard. In addition, bank width of 30 ft including a dowel of 5 ft width and 1.5 ft high has been proposed.

Remodeling of Rasul-Qadirabad (R-Q); Qadirabad-Balloki (Q-B); and Balloki-Suleimanki (B-S) Link Canal System will facilitate diversion of flood water supplies for development of water resources in Smaller Cholistan, besides meeting the shortages in the command areas of existing canals off-taking from various barrages on this water transfer route from Rasul to Suleimanki Barrage. Existing canals which will be benefitted from this remodeling program mainly include Lower Bari Doab (LBDC), Eastern Sadiqia, Fordwah and Hakra Canals.